The Foundry Trade Journal
AND PATTERN-MAKER.
THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 16. **MAY, 1914.** **No. 149.**

PUBLISHED THE FIRST WEEK IN EACH MONTH.

Subscription Terms: 7s. 6d. per annum, post free.

To place the "**Journal**" within the reach of Work—ng Moulde.s and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum' such order to be countersigned by the superintendent or foreman

All communications to be addressed to the Editor, or to the Publis.her, as the case may be, of

The Foundry Trade Journal,
165, Strand, London, W.C.

WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR. MSS SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

BRITISH FOUNDRYMEN'S ASSOCIATION.
LIST OF SECRETARIES—

General Secretary: E. A. Pilkington, Brook House, Sheepbridge, Chesterfield.
Manchester: A. Harrison, 705, Manchester Road, Castleton.
Birmingham: C. Grindlay, 39, Copsley Hill, Erdington, Birmingham.
Cardiff: H. Griffiths, Messrs. J. Williams & Sons, Ltd., Globe Foundry, Cardiff.
Sheffield and District: R. W. Kemlo, 6, Lees Hall Road Meersbrook, Sheffield.
Scottish: J. Paterson, Royal Technical College, Glasgow.
London: T. Murphy, 180, Gray's Inn Road, London, W.C.
Halifax: J. G. Robinson, 17, Gibraltar Road, Halifax.
Newcastle-on-Tyne: H. A. J. Rang, Cleveland Road, North Shields.

Contents.

	PAGE
Notes and Comments	267
A Large Electric Furnace for Pig-iron	269
Suggested Plan for a General Foundry	272
British Foundrymen's Association: Annual Conference	273
Influence of Nickel on Some Copper-Aluminium Alloys	274
The 4.3 per cent. Carbon Eutectic (White Iron) and its Relationship to Iron and Steel Structure	278
Notes on Heat Treatment of Cast Iron	284
Modern Steel Foundry Practice	286
The Foundry Chemist	290
Making Large Cast-Iron Collars	293
Low Carbon Pig-iron in the Foundry	294
Correspondence	295
Foundry Sands and Their Treatment: Tests for Refractory Values	296
A Day in the Foundry	298
Effect of Gases in Steel Castings	302
Improvement in Thermo-Electric Pyrometers	303
F. T. J. Bookshelf	304
Inventions	305
Trade Talk	306
Personal	308
Deaths	308
Parliamentary	308
New Companies	310
Monthly Price List	312

Forthcoming Events.

MAY 12, 13, & 14.
British Foundrymen's Association.—Annual Convention at Leicester.

MAY 30.
British Foundrymen's Association (Newcastle-on-Tyne Branch.)—Open discussion.

NOTES AND COMMENTS.

The Chemist Again!

Once more we find the value of the foundry chemist under discussion, and, as ever, opinions on the matter are more or less at variance. In a Paper on this subject before the Lancashire Branch of the British Foundrymen's Association (see page 290) the author presented a very fair case for the employment of a metallurgical chemist (as distinct from an analyst only) in connection with the foundry's operations; and although some of the statements made call for criticism, we are in agreement with the author on the desirability of linking the knowledge of metallurgical chemistry with practical skill and experience. The subsequent discussion, however, mainly centred, as many past discussions have done, on the claim that mixing on the basis of chemical composition can effectively rule out of consideration the fracture or number grading of pig-iron. In support of this contention was cited the example of the steelmaker, who buys his iron to analysis in order to get the desired results in his work; and the question was asked, "Why cannot the foundryman do the same?" The illustration is somewhat unhappy, for the simple reason that steel making and grey-iron founding are not analogous. The former is a refining process, involving definite chemical reactions and very marked changes in the chemical composition of the metal, and the use of analytic control of the raw material is mainly in selecting material suitable for the particular process being employed, quite regardless of the physical characteristics of the pig-iron as such. The basic open-hearth process, for example, employs an iron which is quite different from that used in the acid open-hearth process, but it would puzzle most chemists to distinguish between the two steels produced. Grey-iron founding, however, is distinctly not a refining process, and provided the physical requirements can be met, the chemical composition of the pig-iron is quite immaterial. Chemical composition is only concerned in so far as it affects the physical qualities of the iron.

It must not be supposed, however, that the failure of the analogy above criticised dismisses the claim that chemical composition is important in grey-iron founding. It merely reduces the matter to a question of whether chemical composition does really represent the physical characteristics of foundry iron. The author of the Paper under discussion unhesitatingly says it does, and that the fracture of the pig does not affect the result in the final casting. To this many practical foundrymen will reply with equal emphasis that two pigs of the same analysis, but with different fractures, do not give the same results. This is, we believe, fairly generally acknowledged. The reason for the extensive research carried out by Mr. J. E. Johnson, Jun., which we discussed in our last issue, was the fact, which he confirmed by experiments, that certain irons possess a quality as they come from the furnace which is preserved on remelting and which reappears in castings of which these irons form an important ingredient. If by analysis is inferred the determination of the constituents usually understood as comprising pig-iron, it would seem idle, in the face of the fact just quoted, to claim that fracture can be disregarded.

It is, of course, open to be proved that a more intimate chemical examination of pig-iron will reveal a chemical explanation for the phenomenon which so far has been observed only physically; but if, for example, that phenomenon is associated with the oxygen content of the pig, as Mr. Johnson claims, accurate chemical control would involve the determination of the oxygen content in addition to the elements now considered by the analyst—an extremely difficult matter. It then would become a question of whether the familiar process of judging by the fracture would not serve practical requirements in conjunction with the present system of analysis. As a matter of fact, this is the basis upon which many foundrymen are already operating successfully—in some cases after having failed to make chemical control alone meet the demands of the case.

An unprejudiced consideration of this subject must inevitably lead to the conclusions that (1) chemical analysis can be made to play an important part in foundry work, and that (2) analysis alone can be as hopelessly misleading as any other form of control in metal mixing. Composition of metal, as at present determined, is not half the story, and unless properly supplemented by practical metallurgical knowledge it is liable to develop a quite unexpected and unpleasant sequel. We are quite in agreement with the foundry foreman being supplied with analyses of his metals, for these afford most valuable information when taken in conjunction with other factors; but to use that information the foundryman must be a "practical metallurgist." If, on the other hand, the chemist is to control the metal he must not only apply his knowledge of analysis, but also a similar practical metallurgical knowledge There appears to us to be no more difficulty in training the foundryman to couple the application of chemistry with practical metallurgy than there is in training the chemist in the complex requirements of practical founding. In fact, some chemists are distinctly adverse to a fair consideration of metallurgy from the moulding floor. At the same time, the foundryman cannot personally make the necessary determinations and investigations which fall within the laboratory's scope, and it is this fact which makes the chemist necessary. The matter may be condensed into this: That chemistry in foundry work can only be employed successfully in conjunction with practical metallurgical knowledge, and it does not matter whether the one who applies it calls himself a foundryman or a chemist, he will still be virtually manager of the mixing and melting department; and if he attempts to work on analysis alone, sooner or later there will be trouble.

Leicester Foundry Conference.

This month witnesses the recurrence of the annual foregathering of members of the British Foundrymen's Association from all parts of the Kingdom. The venue this year is Leicester, a town which is probably more associated with the woollen and boot and shoe industries than with the foundry trade, but which has, nevertheless, something like a hundred foundry, engineering and similar works within its boundaries, and has also the distinction of being the home of the President of the Foundrymen's Association. Since, also, Leicester is reasonably accessible from a wide industrial area, a record gathering at this year's Conference may be expected. An interesting programme of visits and social functions will supplement the strictly business sessions, and at the latter a series of important papers will be presented.

This annual gathering of foundry experts from all quarters of the country is significant of the change which has during recent years come over the foundry world. Whereas, within the memory of men just out of their apprenticeship, secrecy was the keynote of foundry operations, to-day it is exchange of information, ideas and experience. The benefit is incalculable, and even during the brief life of the British Foundrymen's Association the effect on the trade has been most marked. Many prejudices have still to be broken down, and much steady and strenuous work will have to be performed before the foundry trade can truly claim to possess the spirit of modern progress; but the movement has become too well established to fail now, and it is rather a question of who will fall most readily into line with the requirements of the times than whether the trade generally will do so. That the Foundrymen's Association has been largely responsible for the forward movement cannot be doubted, for it has set hundreds of men thinking whose conceptions of progressive industry would have remained unborn. It remains now for the Association to consolidate continuously as time goes on, the influence it has commenced to exert, until it attains such a position of importance and responsibility in the eyes of the engineering world that its lead cannot be ignored. This can only be done by enlisting the aid of the best workers in all branches of the trade, so that the Association may be accepted as representing the brains of the progressive foundry world. It is here where the Branches individually assume their real importance. On such occasions as the present, one is perhaps liable to overlook the fact that in the Branch activities of such an organisation lies its true virility or its weakness. The Foundrymen's Association is fortunate in that it is essentially composed of a number of virile Branches, each operating independently within its own sphere and each strongly supported by an executive which is actuated solely by a desire for the welfare of the trade. It is at these Branches that the real work of the Association is done, for at their meetings the members meet on terms of easy friendship and can discuss without restraint the host of seemingly trivial and unimportant matters which are concerned so intimately with the success of the foundry's daily work. It is the Branch meetings that reveal the fund of valuable knowledge possessed by the practical man, and also the great need of co-ordinating that knowledge and sifting out the beliefs that are only relics of past prejudices and ignorance.

Time will necessarily be required for this work, but it is steadily proceeding, and when the desirability of co-ordinated knowledge is better appreciated among practical workers, the progress will be more rapid. In the meantime the foundryman's thoughts turn to Leicester and the forthcoming Conference, where he may meet his contemporary from the other end of the land, and exchange ideas and experience to mutual advantage. The meeting will be a pleasant one, and few will willingly miss it.

Institute of Metals—May Lecture.

Professor E. Heyn, of Berlin, the noted German scientist, is this year to deliver the annual May lecture before the Institute of Metals. Professor Heyn has given the title of his discourse as "Internal Strains in Cold Wrought Metals, and Some Troubles Caused Thereby." The lecture will be given in the building of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., under the chairmanship of Admiral Sir Henry Oram, K.C.B., F.R.S., the President of the Institute of Metals, on Tuesday, May 12, at 8.30 p.m., and the Secretary of the Institute of Metals, Mr. G. Shaw Scott, M.Sc., of Caxton House, Westminster, S.W., will be glad to forward tickets to any readers who may desire to be present.

A Large Electric Furnace for Pig-iron.

At a recent meeting of the Christiania Polytechnic Association Dr. A. Helfenstein, of Vienna, the well-known inventor and metallurgist, read a Paper on "Electric Furnaces," in which, after discussing the various features which characterise the processes in electric smelting furnaces and which closely influence their construction, he described a large electric furnace for smelting iron ore which has been installed at Domnarfvets.

FIG. 1.—EXTERIOR OF FURNACE.

On the basis of the experience gained with the large electric carbide and ferro-alloy furnace, Dr. Helfenstein and his assistants have turned their attention to the problem of manufacturing electric pig-iron direct from iron ore, and the first furnace for this has been erected at the Domnarfvets Iron-works in Sweden. The fundamental principle of this furnace has already been described. It is, however, necessary to point out that no shaft has been employed for the materials, as the main object has been to make the construction as plain and simple as possible. The furnace was in a way an experimental one, from which the furnace gases were drawn from a point as near as possible to that of their development. It is, however, by no means impossible that shafts may be employed for other furnaces in future. The furnace was started in May, 1913, and has now been working satisfactorily from the very start. It was designed for a capacity of 10,000 to 12,000 h.p., and the conducting cables were dimensioned accordingly, although it turned out that in the long

run it was quite impossible to get the above-mentioned amount of energy, for the simple reason that the power station at Domnarfvets was provided with generators the number of periods of which was quite abnormal. The generators are working with 62 periods, which for large quantities of energy causes a phase-displacement that far exceeds the permissible figure for a load of 10,000 h.p. It was therefore decided to employ from 6,000 to 8,000 h.p. only, and it transpired that with this load (120 volts between the phases and 26,000 amperes per electrode bundle), it was possible to limit the phase-displacement to 0.8.

The maximum output of pig-iron per 24 hours was 65 tons, while the output per month varied between 1,200 and 1,600 tons. While charcoal was being employed as reducing material the average consumption of energy and materials was as follows :—

Consumption of Energy per ton of pig-iron 2,000 kw.-hours.

Consumption of Charcoal per ton of pig-iron 6 to 8 cwts.

Consumption of Electrodes per ton of pig-iron 15½ lbs.

The value of the furnace gases varied between 2,800 and 3,000 calories per cubic metre of gas. From this it may be seen that the results in respect of the consumption of energy are not so favourable as those achieved in the Electrometals furnace, and the same may be said as to the consumption of charcoal, while that of electrodes is about the same as in the Electrometals furnace, as it can be safely assumed that the consumption can be brought down to 11 lbs. per ton of pig-iron. This furnace has, however, on the other hand certain advantages as compared with the Electrometals furnace, which are as follows :—

(1) The capital expenditure is considerably lower, viz., only about 55s. 6d. per h.p. for the whole plant, while an Electrometals plant of corresponding size would cost about 89s. per h.p.

(2) The furnace gases possess a considerably greater value, as they are equal to 2,600—3,000 calories per cubic metre, while those in the Electrometals furnace have only a value of 2,300 calories.

(3) The whole process can be much better controlled and overlooked, and the furnace worked much more easily. These large furnaces can, for instance, be started much more quickly than the large shaft furnaces, and it has been proved that even after a stoppage of 2 to 3 days the furnace can be started and have the full load on in the course of 10 to 15 minutes, and after a few hours the tapping can take place quite normally. It is of great importance that additional materials for improving the charge be added to it close to the melting zone, because the effect will then be almost immediate, while it may take hours before such admixtures are able to reach the melting zone in a furnace with a high shaft.

(4) A pulverised ore can be employed without the working of the furnace being hampered in any way, and it need scarcely be pointed out that this is one of the greatest and most important advantages of the whole system. In the Domnarfvets furnace slig up to 70 per cent was in this way employed in the charge (without briquetting), but the process was not obstructed in any way. A trial was also made by

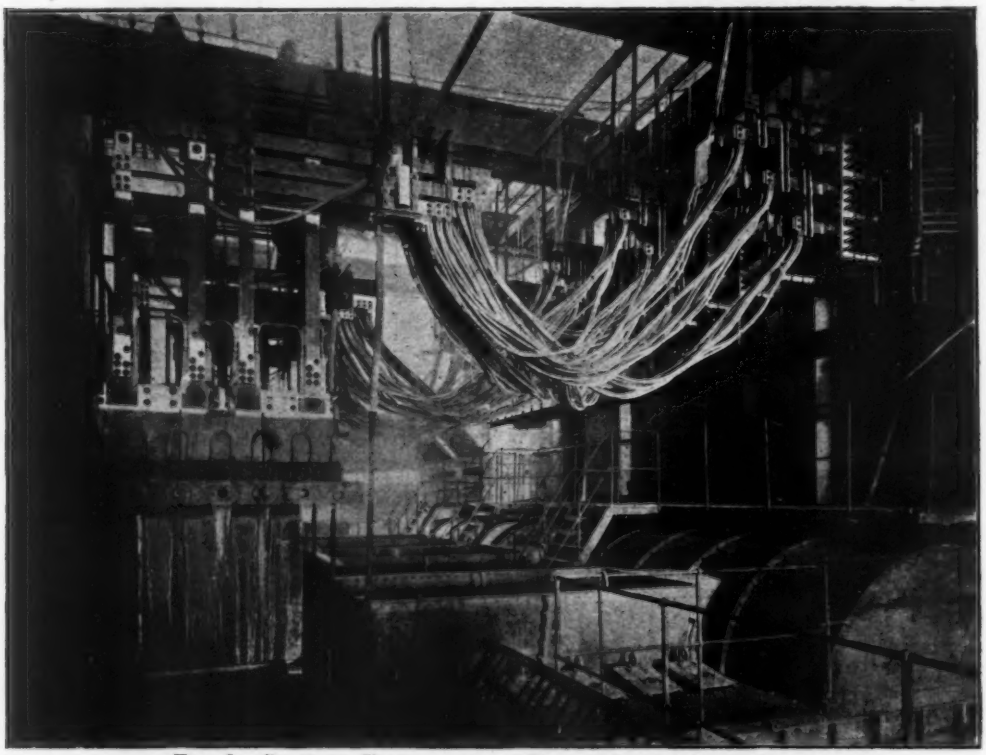


FIG. 2.—CHARGING FLOOR, SHOWING ELECTRODES AND CONDUCTORS.

adding 30 per cent. of dust from the throat of the furnace to the charge, but even in this case the smelting process proceeded quite normally.

(5) The number of attendants required for the working of the furnace is very small; a furnace with a capacity of 10,000 h.p. needs only seven men per shift, viz., three chargers, one to control the regulation, and three men for the tapping.

(6) The furnace allows of coke being used as reducing material, and this is one of the most important points in the problem of the electrical production of pig-iron. If coke is to be employed as a substitute for charcoal, there are two conditions which must be fulfilled :—(*a*) The tension in the smelting furnace must be lower, and the density of the current in the electrodes must be higher. (*b*) The furnace gases must be removed after having passed through the comparatively thin layer of materials in the melting chamber. It is a peculiar feature of large furnaces that a higher voltage can be used than in small furnaces, no matter what the process in question is. This is also the case when coke is employed as a reducing medium, but the voltage cannot be kept on the same level as when charcoal is employed. With charcoal the furnace can easily be worked with 70 volts per phase, while this figure with coke must be reduced to 50—55 volts per phase. This is explained by the fact that coke is an excellent conductor.

It must, however, be added that the development in this direction is not to be regarded as terminated, and it is thus quite probable that the voltage can in future be raised considerably with coke as the reducing medium. The working with coke requires a higher density in the electrodes on account of the lower voltage and the higher weight of the ore per unit of volume. With charcoal the furnace can be run with a density in the electrodes of 2—3 amperes per square centimetre, while 4 or preferably 5—6 amperes per square centimetre are required with coke. Owing to these circumstances, and in consequence of the abnormal number of periods of the electric generators at Domnarfvets it became necessary to reduce the load of the furnace to only 5,000 to 5,500 h.p. when coke was employed, but with this load there were no difficulties experienced with the working.

The second condition for the employment of coke is a speedy removal of the furnace gases. Low-shafts are consequently the only ones that can come into question for such furnaces, because the furnace gases then will have to pass through only a thin layer of the charge. This has, however, the drawback that the reducing power of the gases is imperfectly utilised. The consequence is that a gas rich in CO will be produced, while the consumption of energy and of coal will increase. It has thus been proved at Domnarfvets that the consumption of energy has risen to 2,400 kw.-hours per ton of pig-iron, while the consumption of coke amounted to 6 to 6¼ cwts. As regards the consumption of electrodes, this was kept on the same level as when charcoal was employed.

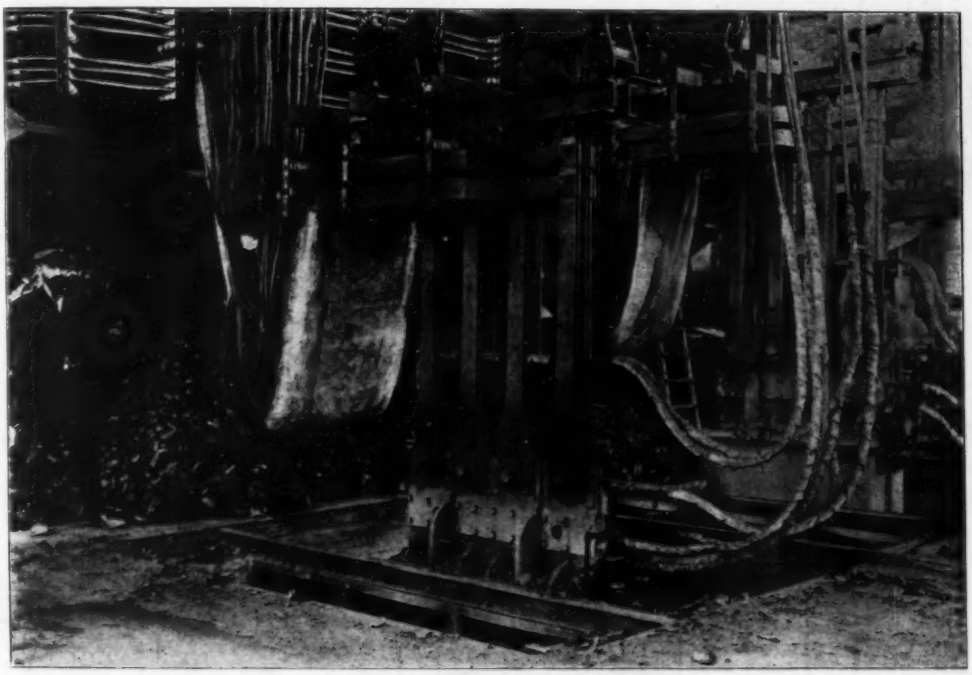


FIG. 3.—ELECTRODES IN THE FURNACE.

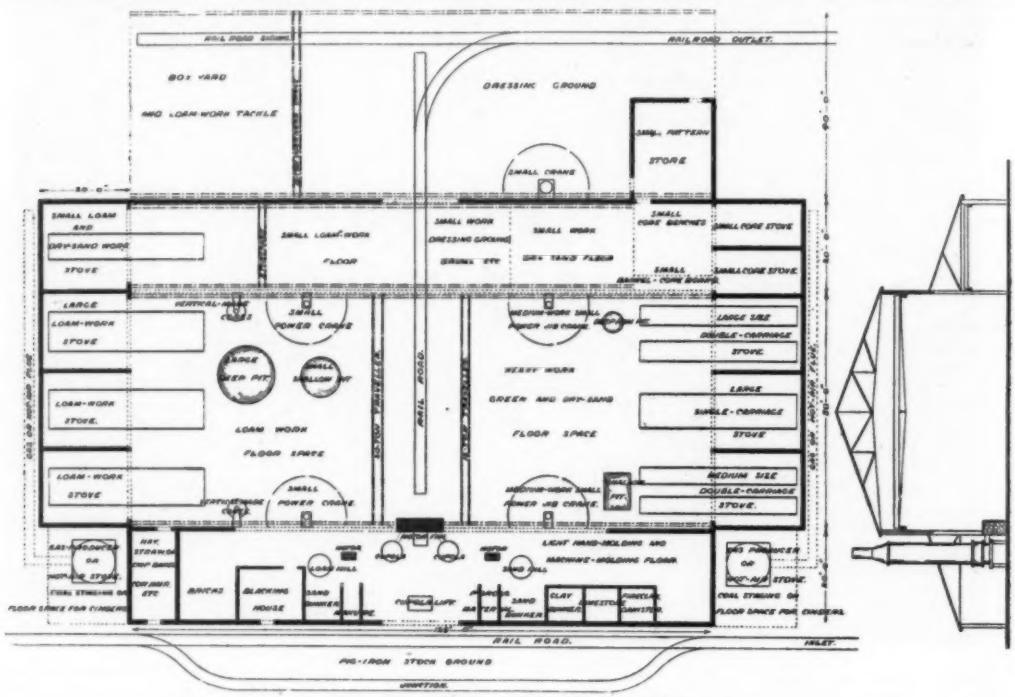
In ironworks which are only occupied with the manufacture of electric pig-iron, the most natural solution of the gas question would be to connect the main furnace with rotating furnaces, so that the iron ore could be subjected to a pre-reduction by the aid of the furnace gases before entering the large furnace proper. This would, of course, effect a great saving in the consumption of energy, coke and electrodes per ton of pig-iron produced. Secondly, it can be used for open-hearth furnaces. The furnace gases at Domnarfvets are now so employed, and the gas pipes from the large electric furnace are conducted directly to the steel department.

Suggested Plan for a General Foundry.

By Sidney G. Smith.

(*All Rights Reserved*).

The layout and general arrangement of an iron foundry capable of a large output of general castings per week, either in loam or sand, is so important that its existence as a paying concern may depend upon the forethought and expert knowledge expended upon it. Leaving aside the building as a structure, and its strength, etc., ample light and ventilation must be provided, as this will enhance healthy and beneficial conditions of working. Artificial light should only be used when absolutely necessary, *i.e.*, when the natural light cannot be supplied, and this will be found true economy. Ample ventilation will promote efficiency of the workers by keeping them healthy; consequently they will be able to get through the work with more ease, and exercise their intelligence in the performance of it. Unfortunately, the reverse of the foregoing too frequently exists. It has often perplexed the understanding of the writer, why an iron foundry should so often be a dark, dismal place. Surely there is no craft under the sun that requires more of its light than does the foundry.



Suggested Plan for a General Foundry.

Some of the all-important considerations in designing and building a new foundry are as follows:—

(1) All material required for the foundry alone should be taken to a place that is in close proximity to where it is required first hand, and that should be done by the simplest and most direct means regarding convenience and conveyance. That is to say, everything going in, after being utilised for the purpose intended, should be on its way out. Such materials as pig-iron, limestone, coke, moulding sand, coal dust, blacking, bricks for loam moulders, core-barrel bands, cow-hair, manure, etc., for the loam mills, could with line or lines enter on their journey from the cupola side of the foundry, and be deposited in places allotted to them.

(2) The internal plan of the foundry should be such that it is no great inconvenience to make castings either in sand or loam up to 20 tons weight. This involves forethought regarding lifting power. Convenient provision should also be made for medium-sized castings and the smallest castings, moulding machines, etc., which involves several considerations regarding overhead travelling cranes, small cranes, their position and general utility.

(3) The dressing ground and box yard should receive special attention, because in this direction there is a possibility of a great waste of time and expense. The dressing ground and shops for both large and small work should adjoin the foundry. Also, the box yard should be in close proximity to the moulding shop, in order that changes may be made quickly and without undue loss of time in transit. These are some of the items that go towards making a self-contained and economically-working foundry.

In the accompanying sketch the writer has embodied the best points in the foundries he has seen, coupled with the results of his own experience, to

make an ideal, economical and practical working foundry. The great draw-back to most large foundries of ancient date is that addition after addition to the plant, covering a number of years, due to increasing business, has made the handling of material very expensive. Of course, the sketch shows a foundry laid out on open ground, without any encumbrances; still the space occupied is not extravagant. The wagon lines and approaches are as few as practical for working a large foundry without undue stoppages.

Taking the cupola side of the foundry as the inlet, which is quite natural, and the dressing ground as the outlet, then all castings will be working one way. There is one exception to this rule, but it does not refer to castings. The slag, dirt, etc., from the cupolas must return by the inlet road. It will be noticed there is a double junction line immediately in front of the cupolas; this provision should obviate any stoppages when material of any kind may be coming in, or out, in this side during any time of the day, and should make it possible by shunting to reach any of the bunkers at any time without delay to the routine work. A glance at the plan at the entry side will show that provision is made for most things that a foundry requires. Space is provided for pig-iron and scrap for immediate use. Of course, if a large selection of stock iron is kept, then a piece of ground for that purpose must be set apart near to the cupolas, and to this end the selectors stock of different brands of iron not for immediate use could be stacked on the left-hand side of the line or junction opposite the cupolas.

The plan of the interior of the foundry is laid out for general work of any kind, and stoves are placed at either end; one end for green sand and dry sand, the other end for loam work. The small bay at the entry side is allocated for small work and machine moulding on account of the nearness to the cupola, and consequent convenience when casting with small ladles. In the middle bay 20- and 15-ton overhead travellers are installed for the heavy work. The smaller power jib cranes are spaced out for medium work, and can be used to relieve the travellers, which are often required for up and down shop work. Plenty of crane power judicially placed is a great asset in a general foundry, and strange to say, it is a matter often overlooked. For instance, if only two or three sets of men had to wait several times a day for a lift, it would soon amount to many hours of wasted time, and as time is money during working hours, it is easily seen that a continual leakage of this kind would soon make itself felt in the cost of production.

The dressing shops for the small work, drums, etc., are placed under the left-hand bay, at the sand end of the foundry. The place for making small cores is a continuation under the same bay. The dressing ground for large castings is outside the foundry proper at the sand end, and may, or may not, be covered in. Part of this ground should be covered by the rake of a jib power crane, and the whole of it by the overhead traveller. At the loam end of this ground, running parallel with the foundry wall, is the box yard. It is a great mistake to have the box and tackle yard any distance from the foundry. For a foundry to be economically worked it must be practically self-contained, *i.e.*, with the exception of incoming material and outgoing castings, it should be independent of outside departments. The travelling crane covers the box and tackle yard, as well as the dressing ground for large castings, and can be utilised for loading and unloading both.

In regard to casting pits in the foundry, three pits will be more or less required for casting certain work, such as large steam cylinders, liners, hydraulic rams and cylinders, pans, pipes, columns, etc., and should be made water-tight by means of iron shells, or casing, cementing, or bricking. There is now a demand for hydraulic rams and cylinders up to 36 ft. long, and a large general jobbing foundry would not be complete for such work without a pit at least 30 ft. deep by 8 ft. diameter, because such castings to be solid and of uniform density (which is absolutely necessary) must be cast in a vertical position. This pit, owing to the demand not being continuous, should be located in a part of the foundry that would not inconvenience the general work. Hence, it is placed where it is most likely to be out of the way. Of course, it can be covered when not in use.

British Foundrymen's Association.

ANNUAL CONFERENCE.

It is announced that the annual Conference of the Association will be held in Leicester on Tuesday, Wednesday, and Thursday, May 12, 13 and 14. The meetings will be held in the Lecture Hall of Leicester Technical School, and the headquarters of the Conference will be at the Grand Hotel. The local secretary, Mr. S. H. Russell, Bath Lane, Leicester, will be glad to answer all enquiries. The programme is as follows:—

Tuesday, May 12.

Morning at 9.30.—Business meeting, followed by President's Address. Discussions on "Annealed Castings for Textile Machine Spindles," by Mr. R. Buchanan (Birmingham), and "Cores, with Special Reference to the Use of Silica Sand," by Mr. F. C. Pulsford (Leicester).

Afternoon.—Visit to Works of the British Thomson-Houston Company, Rugby.

Evening.—Reception by the Mayor and Mayoress of Leicester (Councillor and Mrs. J. Russell Frears).

Wednesday, May 13.

Morning at 10.—Discussions on "Some Considerations in the Design and Working of Foundry Cupolas," by Mr. E. L. Rhead, M.Sc.,Tech., F.I.C. (Manchester School of Technology); "Foundry Yields," by Dr. Percy Longmuir (D.Met.), and Mr. W. H. Robinson (Sheffield); and "Production of Plaster-of-Paris Patterns," by Mr. C. Heggie (Birmingham).

Afternoon.—Visit to Midland Railway Company's Works at Derby.

Evening.—Smoking concert at the Grand Hotel, Leicester.

Thursday, May 14.

Motor drive round Charnwood Forest, calling at Cropstone Reservoir and Pumping Station, and taking lunch at Stoneywell Cottage, Ulverscroft, by invitation of Mr. Sydney A. Gimson (President) and Mrs. Gimson.

The Corrosion of Lead.

Recent experiments have shown that lead is corroded in an alkaline as well as an acid medium. Lead is readily attacked by weak organic acids, and is slowly dissolved by H_2O containing air. The waters which are most liable to act on lead are those obtained from upland gathering grounds, waters which are soft and usually of remarkable purity. The corrosion of water pipes by electrolysis is reported, the lead joints being the first affected.

Influence of Nickel on Some Copper-Aluminium Alloys.

In the course of a Paper on this subject read before the Institute of Metals, last March, by Professor A. A. Read, M.Met., F.I.C., and R. H. Greaves, M.Sc. (University College, Cardiff), the authors dealt at considerable length with the results of experiments conducted on alloys which were tested (1) as cast; (2) as annealed rods; (3) as cold-rolled rods; and (4) as quenched rods. We append an abstract of the Paper so far as it relates to the cast-metal tests :—

The authors undertook to investigate the influence of nickel, chiefly on two typical commercial copper-aluminium alloys, namely, those containing 5 and 10 per cent. of aluminium respectively. For the purpose of carrying out this research the following materials were procured :—

Electrolytic or cathode copper of very high purity from Messrs. Vivian & Sons, Swansea.

Shot nickel containing at least 99.8 per cent. of nickel from the Mond Nickel Company; this, on analysis, gave :—Silicon, 0.01 per cent.; iron, 0.04 per cent.

Aluminium of guaranteed purity, 99.5 per cent., from British Aluminium Company; this was found on analysis to contain :—Silicon, 0.17 per cent.; iron, 0.18 per cent.; sodium, 0.05 per cent.

The nickel was introduced into the alloys in the form of 50 per cent. cupro-nickel. The whole of the nickel required was placed in a Salamander crucible with two or three layers of copper towards the top, and covered with lump charcoal. The crucible was heated in a coke wind furnace, and the remaining copper added as the charge sank down in the pot. Much quicker melting was attained by this method than by charging alternate equal layers of nickel and copper, and so reserving some nickel as well as copper to add as the charge melted down. The molten metal was well stirred with a graphite rod, and poured into cylindrical chill moulds.

Preliminary Experiments.

Small trial ingots weighing about 300 grammes, containing varying amounts of copper, nickel and aluminium, were cast in open chill moulds. The values of the relative hardness, recorded with the compositions of these ingots in Table I., were obtained by means of the Shore scleroscope, using the universal hammer :—

TABLE I.—*Composition and Relative Hardness of the Small Ingots.*

No.	Composition.			Relative Hardness.
	Copper.	Nickel.	Aluminium.	
	Per cent.	Per cent.	Per cent.	
a.	89.55	0.97	9.48	23.0
b.	85.15	4.94	9.91	33 0
c.	80.13	9.98	9.81	35.0
d.	75.13	14.95	9.92	32.0
e.	94.04	0.92	5.04	10.0
f.	90.09	4.90	5.01	10.5
g.	85.08	10.07	4.85	22.0
h.	79.99	15.26	4.75	36.0
i.	97.75	1.03	1.22	7.0
j.	95.21	3.57	1.22	8.0
k.	89.24	9.83	0.93	9.0
l.	84.54	14.58	0.88	13.0

Colour.—The effect of nickel was in all cases to make the golden colour of the alloys paler, but its influence was much more marked in the 5 per cent. series than in the series with 10 per cent. of aluminium. Thus the alloy with 5 per cent. of aluminium and 15 per cent. of nickel showed only a slight yellow tinge, and was much whiter than the metal with the same quantity of nickel and 10 per cent. of aluminium. The colour of the alloys with 15 per cent. of nickel was almost a silvery white, but in none of them was the characteristic golden colour of the copper aluminium alloys entirely destroyed.

Final Experiments.

The copper and cupro-nickel were melted together under charcoal in a Salamander crucible, heated in a coke wind furnace. When all the metal had melted and had attained a good temperature, it was well poled, and the aluminium which had been heated up almost to its melting-point was forced down into the molten metal. The aluminium at once melted and dissolved in the copper. In each case, on the addition of the aluminium, a marked rise in temperature was observed. The metal was well stirred with a graphite rod to ensure thorough mixing, the crucible was withdrawn, and the metal skimmed and teemed at as low a temperature as possible into a circular cast-iron chill mould, following up with fluid metal from the pot to avoid the pipe which would be caused by shrinkage. The ingots for rolling thus cast were 2¼ inches in diameter, 18 inches in length, and weighed about 20 lbs. The time from charging the cold metal to teeming was about one hour. The maximum loss of aluminium was 0.4 per cent., the average loss being about 0.2 per cent. There was no loss of nickel. Ten ingots were cast, and on analysis gave the results shown in Table II. :—

TABLE II.—*Composition of the Ingots.*

No.	Copper per cent.	Nickel per cent.	Aluminium per cent.
1	89.94	—	10.06
2	89.14	1.04	9.82
3	87.66	2.46	9.88
4	85.11	4.95	9.94
5	82.82	7.48	9.70
6	94.98	—	5.02
7	93.96	0.94	5.10
8	92.68	2.38	4.94
9	89.84	4.84	5.32
10	87.48	7.31	5.21

The chill castings included in the tests were 1 in. in diameter and 10 in. long, and were made in pairs under the same conditions as the larger ingots already described. The tests were carried out on a Buckton universal horizontal testing machine fitted with a Wicksteed recorder. From the autographic stress-strain diagrams thus obtained the yield points were measured.

Results of Tests on Cast Alloys.

The following is a summary of the effect of nickel on the mechanical properties of the cast alloys: any marked discontinuity in the mechanical properties was in nearly every case found to be associated with a change in the microstructure.

Aluminium, 10 per Cent.—With the chill castings

increased maximum stress and yield point are obtained up to 10 per cent. of nickel, at the expense of elongation and reduction of area. Above that point all the properties diminish. The 10 per cent. nickel alloy in the form of chill casting is improved by annealing at 900 deg. C.

Specific Gravities.—The specific gravities of the alloys as chill castings are given in Table V. In spite of the fact that the density of nickel (8.80)* is less than that of copper (8.93), it will be seen that the presence of nickel brings about a distinct increase in the specific gravity, this being most marked in the

TABLE III.—*Tensile Tests of Chill Castings.*

No.	Composition.			Yield point. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation per cent. on 2 ins.	Reduction of area per cent.	Remarks.
	Copper per cent.	Nickel per cent.	Aluminium per cent.					
20 C	90.00	—	10.00	11.6	30.43	19.4	27.2	Fracture pale gold, silky. Surface slightly wavy.
21 C	89.48	0.96	9.56	12.8	35.50	20.2	21.5	Fracture pale gold, coarsely granular. Surface slightly wavy.
12 C	85.26	5.18	9.56	19.9	39.80	7.2	10.1	Fracture greyish, coarsely granular. Surface very slightly wavy.
13 C	79 94	10.14	9.92	25.1	38.48	2.8	4.6	Fracture grey, finely granular. Surface smooth.
22 C	75.34	14.62	10.04	16.5	29.18	3.2	5.5	Fracture grey, finely granular. Surface smooth.
19 CA	80.39	10.00	9.61	19.3	37.19	15.0	17.8	Annealed. Fracture grey, finely granular. Surface very slightly wavy.
23 C	94.88	—	5.12	5.0	18.73	68.0	58.2	Fracture pale gold, silky. Surface very wavy.
15 C	93.94	1.00	5.06	5.5	19.26	92.1	69.1	Fracture pale gold, silky. Surface very wavy.
16 C	90.04	5.05	4.91	5.6	18.67	86.5	73.4	Fracture very pale gold, silky. Surface wavy.
17 C	85.03	9.42	5.55	15.0	28.27	39.7	39.0	Fracture whitish grey, radially slightly crystalline. Surface wavy.
18 C	79.90	14.90	5.20	35.1	41.56	4.7	10.0	Fracture pinkish grey, radially crystalline. Surface smooth.

Aluminium 5 per cent.—With the chill castings nickel up to 5 per cent. greatly improves the elongation and reduction of area of these alloys without affecting the maximum stress and yield point. With more than 5 per cent. of nickel, the latter properties are rapidly improved, while the elongation and reduction of area suffer a corresponding decrease. Nevertheless, the yield point and maximum stress are both raised by about four tons per sq. in. before the ductility is reduced to that of the pure copper-aluminium alloy. The increase in elongation and reduction of area due to the first 1 per cent. of nickel is very marked, the chill casting showing an elongation of 92 per cent., compared with 68 per cent. for the corresponding copper-aluminium alloy without nickel.

TABLE IV.—*Hardness Tests of Chill Castings.*

No.	Composition.			Hardness Number.	
				Scleroscope	Brinell (Load of 3,000 kilogrammes)
	Copper per cent	Nickel per cent	Aluminium per cent.	Chill castings.	Chill castings.
1 ..	89.94	—	10.06	20.0	135
2 ..	89.14	1.04	9.82	33.0	150
3 ..	87.66	2.46	9.88	36.5	176
4 ..	85.11	4.95	9.94	41.0	199
5 ..	82.82	7.48	9.70	35.0	179
13 ..	79.94	10.14	9.92	35.0	182
14 ..	74.26	15.75	9.99	32.0	182
6 ..	94.98	—	5.02	9.0	58
7 ..	93.96	0.94	5.10	10.5	59
8 ..	92.68	2.38	4.94	11.0	59
9 ..	89.84	4.84	5.32	12.0	60
10 ..	87.48	7.31	5.21	13.5	77
17 ..	85.03	9.42	5.55	17.0	115
18 ..	79.90	14.90	5.20	37.0	173

TABLE V.—*Specific Gravity (expressed as Grammes per Cubic Centimetre) of Chill Castings.*

No.	Composition.			Specific gravity.
	Copper.	Nickel.	Aluminium.	
	Per cent.	Per cent.	Per cent.	
1	89.94	—	10.06	7.54
3	87.66	2.46	9.88	7.55
4	85.11	4.95	9.94	7.56
5	82.82	7.48	9.70	7.60
13	79.94	10.14	9.92	7.53
14	74.26	15.75	9.99	7.60
6	94.98	—	5.02	—
8	92.68	2.38	4.94	8.14
9	89.84	4.84	5.32	8.15
10	87.48	7.31	5.21	8.15
17	85.03	9.42	5.55	8.13
18	79.90	14.90	5.20	8.14

10 per cent. aluminium alloy with 5 per cent. of nickel. In this series, with larger amounts of nickel,

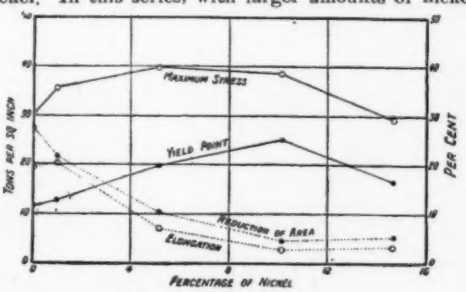


FIG. 1.—TENSILE TESTS.
ALUMINIUM 10 PER CENT. CHILL CASTINGS.

the specific gravity falls in spite of a slight decrease in aluminium. This fact, as well as the differences

* Roberts-Austen, "Introduction to Metallurgy," 1910, p. 67.

between the cast and annealed alloys of the same series, is probably significant in connection with the constitution of these alloys.

Melting-Points.—The melting points of a number of the alloys were determined with a thermo-electric

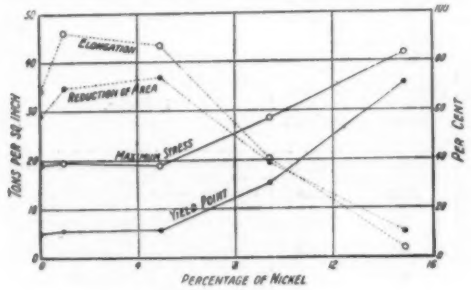


FIG. 2.—TENSILE TESTS.
ALUMINIUM 5 PER CENT. CHILL CASTINGS.

couple and a direct-reading millivoltmeter. The results which are tabulated in Table VI. show that the addition of nickel to the 5 per cent. aluminium-

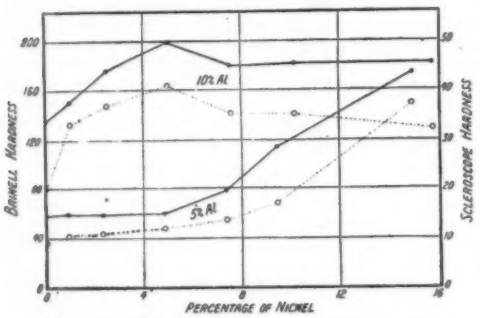


FIG. 3.—HARDNESS TESTS (BRINELL & SCLEROSCOPE ON CHILL CASTINGS.

copper alloy results in an immediate and considerable rise in melting-point; while with the 10 per cent. alloy there appears to be a slight fall at first, followed by a rise before the nickel reaches 5 per cent.

TABLE VI.—*Melting Points.*

No.	Composition.			Melting-point.
	Copper.	Nickel.	Aluminium.	
	Per cent.	Per cent.	Per cent.	Degrees C.
20	90.00	—	10.00	1,042
3	87.66	2.46	9.88	1,039
12	85.26	5.18	9.56	1.042
5	82.82	7.48	9.70	1.053
13	79.94	10.14	9.92	1,079
22	75.34	14.62	10.04	1,063
6	94.98	—	5.02	1,054
8	92.68	2.38	4.94	1,081
16	90.04	5.05	4.91	1,093
10	87.48	7.31	5.21	1,097
17	85.03	9.42	5.55	1,108
18	79.90	14.90	5.20	1,119

Microscopic Features of the Alloys.

All the alloys have been examined microscopically, the specimens being etched as a rule with an acid solution of ferric chloride containing four parts of a solution of ferric chloride in water (1:12), and one part of concentrated hydrochloric acid.

It was necessary, however, in dealing with some of the alloys containing 5 per cent. of aluminium to dilute this to one-quarter strength by the addition of three parts of water, while ammonium persulphate was also found useful in some cases. All the accompanying photomicrographs were taken by direct illumination.

Aluminium, 10 per Cent.—The cast structure of the alloys containing less than 5 per cent. of nickel consists solely of the α and β constituents, exactly resembling those of the 10 per cent. aluminium copper alloy. At 5 per cent. of nickel a few blue veins are visible in the α constituent at a magnification of 350 diameters. At 7½ per cent. of nickel these are more noticeable, as shown in Fig. 4, and penetrate into the β constituent. At the same time the size of the crystals is reduced, and the alloy with 10 per cent. of nickel shows a finer $\alpha+\beta$ structure, with a much smaller proportion of the β constituent, while there are also present crystallites of the blue constituent as shown in Fig. 5. When 15 per cent. of nickel is reached the β constituent is entirely replaced by the greyish-blue substance embedded in a ground mass of the α solution (Fig. 6).

Aluminium, 5 per Cent.—The cast structures of the alloys with 5 per cent. of nickel and under consists of large α crystals which exhibit coring. Micrograph Fig. 7, showing the 1 per cent. alloy, is typical of these; the coring becomes more marked as the per-

FIG. 4.

Copper 82.82
Nickel .. .. 7.48 } per cent.
Aluminium 9.70
Cast. Magnified 100 diameters.

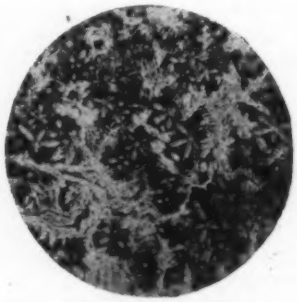


FIG. 5.

Copper 79.94
Nickel .. .. 10.14 } per cent.
Aluminium 9.92
Cast. Magnified 100 diameters.

FIG. 6.

Copper 74.26
Nickel .. .. 15.75 } per cent.
Aluminium 9.99
Cast. Magnified 100 diameters.

centage of nickel increases, but disappears on annealing. The alloy with 7¼ per cent. of nickel (Fig. 8) shows very heavy coring (or probably two constituents) which did not disappear, but was modified by annealing. The second constituent is certainly present in the 10 per cent. nickel alloy, and this at first etches brown, but at 15 per cent. (Micrograph Fig. 9) the alloy consists of long, blue dendritic crystals set in a ground mass of golden a constituent.

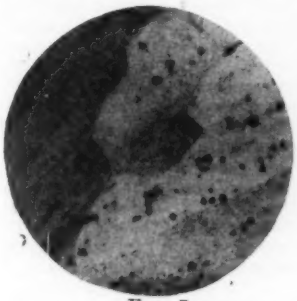


FIG. 7.

Copper 93.94
Nickel .. .. 1.00 } per cent.
Aluminium 5.06
Cast. Magnified 100 diameters.

FIG. 8.

Copper 87.48
Nickel .. .. 7.31 } per cent.
Aluminium 5.21
Cast. Magnified 100 diameters.

FIG. 9.

Copper 79.90
Nickel .. .. 14.90 } per cent.
Aluminum 5.20
Cast. Magnified 100 diameters.

British Foundrymen's Association.

Scottish Branch.

The annual dinner of the Scottish Branch of the British Foundrymen's Association was held recently. The President of the Branch (Professor Campion) occupied the chair.

MR. BALDERSTON, in submitting the toast of the evening, referred in laudatory terms to the valuable work which was being accomplished by the British Foundrymen's Association, and he expressed the hope that numerically the body would grow stronger as the years went on. As they knew, the foundry trade was associated with many worries, and he did not think that there was any position which involved more worries than that occupied by a manager of a foundry. He was sure that the members of the Scottish Branch would accord a very hearty welcome to Mr. Gimson, President of the National Association, and no doubt that gentleman would be able to tell them something of the good work which was being done by the central body.

MR. GIMSON, in the course of an interesting response, said that the Foundrymen's Association was entirely an educational body. Their particular purpose was to help foundrymen as far as was possible out of these troubles to which the previous speaker had referred, and from which no foundryman was immune. They all knew of the many things which could go wrong with castings; the trouble was to find out anything which could not go wrong. (Laughter.) In the Association they met, not as masters and men, but to discuss the welfare of their industry, and by so doing they were helping one another along. He did not think that they would exactly attain to a stage of perfection, even through such intercourse—as a matter of fact, he hoped that they would never reach a stage of perfection, because he could imagine nothing more dull in life than anything perfect. (Laughter.) In conclusion, Mr. Gimson expressed his pleasure at being present with them, and hoped that when next they met it would be at the conference at Leicester. (Applause.)

MR. KING next submitted the toast of "The Branch Association," and, in doing so, he expressed regret that his brother, ex-Baillie King, had not found it possible to be present with them that evening. He was glad to know of the great success which had attended the Scottish Branch since its inception, and while they could already point to a very strong membership they still had great scope for further increase. The work undertaken during the pa year had been of great interest, and he would incidentally mention that a Coke Standard Committee had been appointed. They all knew the difficulties which arose in foundries through the quality of the coke, and there was always more or less trouble arising from this source. This was a question which very materially affected the success of a foundry, because if they used more coke than they intended it meant the throwing away of some of the profit at the end of the year. He hoped that the deliberations of the Committee would lead to good results. Another question which the Scottish Branch was seriously tackling was the apprentice problem, which, as they knew, for many years had been also a source of great trouble. In dealing with the question the Branch had the hearty sympathy and co-operation of the Government Inspector.

PROFESSOR CAMPION, in making acknowledgment, said that the Scottish Branch had now a membership of 180, as against 145 a year ago, and he hoped that this membership would still continue to increase. Continuing, he also alluded to the Coke Standard Committee. The work undertaken by this Committee, he said, was a work of extreme importance, as the economy in fuel in all industries, as well as in the foundry industry, in many cases determined whether a firm was to be financially successful or otherwise. He was afraid that in Great Britain they had been somewhat careless about the fuel question, and possibly that was owing to the fact that they had always been blessed with a plentiful and cheap supply. But things were now altering—competition was somewhat more severe, there was less margin of profit, and it was now necessary to go very carefully into this question.

Prior to the dinner the annual general meeting was held, and office-bearers were elected for the forthcoming year. Professor Campion was unanimously re-elected President; Messrs. Matthew Riddell and R. R. McGowan were respectively appointed as Senior Vice-President and Junior Vice-President; while Messrs. John Logan and J. Paterson were installed as Treasurer and Secretary. Messrs. Doulton, Watt, Lawrie, Bell, Littlejohn, Walker, McQueen, Mathieson, and Robertson were elected as members of the Branch Council.

The 4.3 Per Cent. Carbon Eutectic (White Iron) and its Relationship to Iron and Steel Structure.*

By J. Ernst Fletcher.

In the main recent researches have naturally trended in four directions:—As explaining: (1) The action of carbon on iron; (2) the results of temperature changes in iron and carbon-iron alloys; (3) the action of other metals and metalloids on iron; and (4) the action of other metals and metalloids on carbon-iron alloys.

Researches (1) and (2) have resulted in the development of the "Roberts-Austen-Roozeboom" carbon-iron diagram and the application of the Phase Rule to iron-carbon alloys, whilst (3) and (4) have thrown light on ternary and quaternary alloys, though the complexity involved by the consideration of the apparently heterogeneous group of compounds and alloys is as yet somewhat bewildering. Nevertheless, the practical man, from the mass of information to hand, is now able to see much more clearly the reactions occurring in the processes in which he is daily engaged. Thus light is thrown upon:—

(1) *Carburisation and Decarburisation Processes*: (*a*) The action of carbon in contact with iron and steel at varying temperatures, as in the case-hardening and cementation processes, modified by the accompanying metalloids present: (*b*) the action of temperature and deoxidising actions on cast iron and steels, as in the production of malleable-iron castings and in steel-softening processes.

(2) *De-oxidation Processes* wherein carbon is abstracted from pig-iron and steels by: (*a*) Air blast, as in the Bessemer process; (*b*) slag reactions in puddling, open-hearth and electric furnaces.

(3) *Blast-furnace Phenomena*, such as: (*a*) Reduction of oxides, sulphides, phosphides, etc.; (*b*) slag or cinder reactions and their function; (*c*) carburisation of the reduced iron and manganese; (*d*) reactions of other metals and metalloids on the carburised iron.

Very naturally the research work done has been in connection with the influence of gases, metals, and varying temperature and heat treatment, on pure iron of carbon irons. The results, though invaluable, often confuse the practical issue, and the object of this Paper is to look at the iron-carbon problem from the point of view of that white iron-carbon alloy containing about 4.3 per cent. of carbon, which may be called the basis of all present iron- and steel-making processes.

This eutectic alloy, melting at 1,130 deg. C., is the natural product of the blast furnace. Its composition is slightly altered by the presence of Si., Mn., S., and P. and its carbon extent is affected by the influence of temperature. Notwithstanding this the fact remains that the eutectic is the one "iron and carbide of iron" alloy which provides the means of truly examining the various influences of temperature, other admixed metals and metalloids, etc., on the quality of the iron or steel produced by its decarburisation. Theoretically, the eutectic 4.3 per cent. C. alloy is a white iron—silicon, manganese, etc., free—produced under conditions of low-temperature and pressure air blast, such that the molten metal leaves at the minimum temperature, viz., 1,130 deg. C. or 2,066 deg. Fah. Grey irons are really modified eutectic irons wherein the metals and metalloids Si., Mn., S. and P. by taking up portions of the iron and carbon, have more or less changed the character of the basal eutectic alloy under conditions of higher temperatures than 1,130 deg. C. The latter condition alone, viz., higher temperatures than 1,130 deg. C., in the presence or absence of carbon, may result in white or grey iron respectively.

* Abstract of Paper read, March 21, before the Staffordshire Iron and Steel Institute.

The Eutectic Formation.

A rapid survey of the eutectic's genesis in the blast furnace is useful as showing how the metalloids Si., Mn., S. and P. become entangled in the meshes of the eutectic in its later career. During the descent of the charge (ore, flux, and fuel) the iron reduced in the upper part of the furnace becomes increasingly carburised until at the entrance of the boshes the temperature necessary for the formation of the eutectic is approached, viz., 1,130 deg. C. Below this temperature the slags have not formed; only the limestone having given up its CO_2 and allowed its CaO to descend with the charge to the level of the boshes. As the (CaO-MnO-Al_2O_3-SiO_2) slags only form at temperatures of 1,350 deg. to 1,450 deg. C. it is unlikely that either Mn. or Si. enter the iron at lower temperatures than this. It is most probable that at about the top of the boshes the liquid metal which trickles down into the tuyere regions is the eutectic alloy containing about 4.3 per cent. of carbon. Before it arrives at the tuyeres, however, the slag-fusing zone is penetrated and the Mn. and Si. reactions quickly take place, these exchanges from slag to iron having the character:—

$$3MnO + Fe_3C = Mn_3C + 3Fe + 3CO \qquad (1)$$

Mn_3C replacing the Fe_3C in the fluid eutectic, and

$$SiO_2 + Fe_3C = Fe_2Si + FeO + CO \qquad (2)$$

Silicide of iron entering the liquid setting free oxide of iron (FeO), which is again reduced thus:

$$FeO + C = Fe + CO. \qquad (3)$$

In this relation the writer would refer to Prof. Howe's remarks on blast-furnace reactions. He says:—"The way in which the silicon extent of the pig-iron is controlled is through the controlling of the deoxidation of the silicon of the gangue and ash. This deoxidation takes place readily by reactions such as:

$$SiO_2 + 2C = Si + 2CO. \qquad (4)$$

and any silicon which is reduced is immediately absorbed by the molten iron present. Indeed, the reaction does not readily take place in the absence of iron, but if iron is present to absorb the resultant silicon the reaction is readily affected." The writer maintains that the silicon is absorbed by the eutectic as silicide of iron (Fe_2Si.), and not as metallic silicon, the temperature being sufficiently high and the accompanying slag being of a "scouring" nature contain-

ing FeO. Probably manganese enters the eutectic as Mn_3C. in the manner indicated by equation (1). It is extremely likely that phosphorus enters the liquid metal as phosphide of iron (Fe_3P.), the phosphorus in the slag $4CaOP_2O_5$ attacking the iron liberated when the silicide of iron (Fe_2Si.) and carbide of manganese (Mn_3C.) are formed, or that of the eutectic.

Dr. Stead has stated that when iron silicide (Fe_2Si.) is formed sulphur is reduced, fluid basic silicates dissolving sulphur from fluid crude iron at temperatures between 1,150 deg. and 1,300 deg. C. (the temperature of the boshes). Possibly the exchanges are of this kind:

$$\underbrace{FeO + CaO + SiO_2}_{\text{basic silicate}} + \underbrace{FeS}_{\substack{\text{iron}\\ \text{sulphide}}} \rightleftharpoons Fe_2Si + CaSO_4 \quad (5)$$

and $$CaSO_4 + 4Fe = FeS + 4CaO + 3Fe \quad (6)$$

In further consideration of this action of silicide of iron formation, above alluded to, it will be useful to remember that graphite separation is almost invariably associated with the presence of silicon in liquid cast iron. The action of CO. on liquid Fe_2Si. may be expressed thus:

$$Fe_2Si + 2CO = 2Fe + SiO_2 + 2C. \quad (7)$$

In the preparation of a series of Fe., C., and Si. alloys it was found that SiO_2 as slag particles was often intermingled with the alloys, especially when the temperature of fusion had greatly exceeded that necessary for the production of the silicide Fe_2Si., the alloy containing 20 per cent. Si., 80 per cent. Fe. The SiO_2 was probably present as a ferrous silicate fusible at the temperature given by H. O. Hofman.

FeO. SiO_2 temperature of formation, 1,110 deg. C.
2FeO. SiO_2 temperature of formation, 1,270 deg. C.
3FeO. SiO_2 temperature of formation, 1,220 deg. C.

The microscope revealed slaggy particles mixed with the Fe_2Si. crystallites in a matrix of 4.3 per cent. C. eutectic.

From the above considerations we may conclude that the alloy reaching the hearth of the blast furnace is a diluted eutectic, a portion of whose carbide has been decomposed by the entrance of the iron silicide, yielding graphite and free iron; manganese carbide has displaced some of the iron-carbide portion, whilst iron-phosphide and sulphide have displaced a portion of the free iron.

In a representative cast iron containing:—Carbon, 4.0 per cent.; silicon, 2.0 per cent.; manganese, 1.0 per cent.; phosphorus, 1.0 per cent.; and sulphnr, 0.10 per cent., the distribution of the compounds in the liquid state may be as follows:—

	Free Fe	Fe_3C.	Fe_3P.	Fe_2Si.	MnS.	FeS.	Mn_3.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
F. ..	24.35	53.76	5.5	8.0	—	0.09	—
C	—	3.94	—	—	—	—	0.06
Si. . ..	—	—	—	2.0	—	—	—
Mn ..	—	—	—	—	0.09	—	0.914
S	—	—	—	—	0.051	0.05	—
P . ..	—	—	1.0	—	—	—	—
Total ..	24.35	57.90	6.5	10.0	0.14	0.14	0.97

The Eutectic White Iron.

The eutectic white iron, containing 4.2 to 4.3 per cent. carbon, when quenched briskly from the melting temperature has the composition:—Iron carbide crystals (6.67 per cent. C.), 50 per cent.; austenite crystals (1.80 per cent. C.), 50 per cent. This has the characteristic structure shown in Fig. 1, and consists of successive layers or sheets of porous cementite the pores of which are filled with austenite or its transitional forms—martensite, sorbite or pearlite—if quenched below 1,000 deg. C. A close examination

Fig. 1.

reveals the very interesting history of the eutectic growth:—

(1) The liquid alloy containing gases in solution, in cooling down towards the freezing temperature is not a heterogeneous mass but even when liquid consists of regularly arranged particles of iron probably intermixed with carbide of iron. The iron particles carburised by contact with the carbide of iron attain the composition 1.8 per cent. carbon (saturated austenite) and in solidifying expel their occluded gases into the still liquid carbide, penetrating same by a multitude of minute shafts into which the austenite follows. Almost simultaneously the carbide of iron solidifies, taking its characteristic plate crystal form. The minute gas paths are directed towards the axial planes of the carbide plate crystals, which may possibly form first as hollow crystals, building themselves up from the outside and solidifying inwards as the gases escape. The central mass of the "austentite + carbide" crystal is found to be a sheet or sheets of iron carbide, often plainly seen to have a flow-line structure, and indicating thereby probably the direction of the gases expelled at the time of the solidification of the centre of the carbide crystal. The flow lines have a definite direction and show that there is a gas flow at the time of solidification in the direction of the ingot "pipe" or casting "feeder" head. Such flow is indicated clearly in the "chill" structure of a strong iron low in silicon contents, and especially so if manganese or chromium are present.

A white iron of high carbon content (4 to 4.5 per cent.) heated to 1,050 deg. C. and slowly cooled may become grey. If it does so it is certain that the temperature of fusion when being smelted in the blast furnace exceeded 1,130 deg. C. Any carbon present in excess of 4.3 per cent. (or lower if silicon is present) will separate out as graphite, and once the separation commences it continues until the carbon of the eutectic (originally carbide of iron) is decomposed. The more slowly the cooling the more the decomposition of the carbide is complete. The carbon content of irons containing silicon, as determining the rapid decomposition of the carbide at temperatures above 1,130 deg. C. is, from examination of a number of such irons, as follows:—

Eutectic iron	0.0%	Silicon		Carbon	4.3%
Pig-iron	0.5%	,,	..	,,	4.20%
,, ,,	1.0%	,,	..	,,	4.10%
,, ,,	1.5%	,,	..	,,	3.97%
,, ,,	2.0%	,,	..	,,	3.87%
,, ,,	2.5%	,,	..	,,	3.76%
,, ,,	3.0%	,,	..	,,	3.65%
,, ,,	3.5%	,,	..	,,	3.55%

If the total carbon in such irons is in excess of the above quantities, then rapid graphite formation occurs. It is hindered, of course, by the presence of manganese, but not considerably unless the latter is above 1.0 per cent.* Again, if the total carbon con-

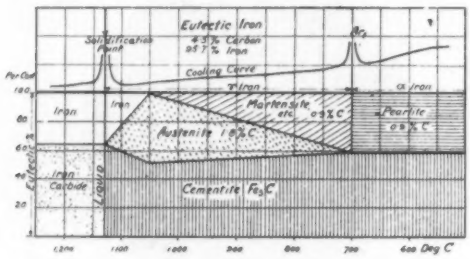


FIG. 2.

tent is less than the above, then there has been an oxidising or "Bessemerising" action in the tuyere zone of the blast furnace, whereby some of the carbon has been burnt.

White eutectic iron, poor in silicon, especially if made by cold-blast with charcoal as fuel, as in Sweden and Russia, retains its carbide much more powerfully than does hot-blast coke iron. It has been repeatedly observed that white pigs of similar analysis used as packings in annealing furnaces (temperatures up to 1,000 deg. C.) become gradually grey—cold-blast pigs slowly, hot-blast pigs rapidly. The hot-blast iron yields much coarser graphite than the cold-blast, and

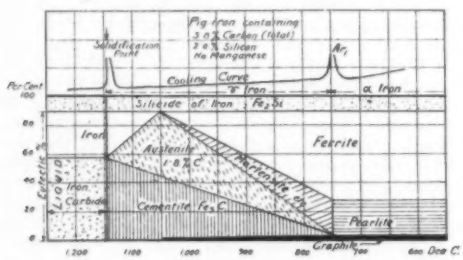


FIG. 3.

in the latter case it is noticed that the ferrite dendritic crystal appears again (after long annealing) in a mass of pearlite in the meshes of which fine temper carbon or graphite is seen. Iron crystallites re-appear in the cooled structure of repeatedly annealed hot-blast irons, but are accompanied by coarse graphite in addition to fine temper carbon. Where the silicon content in such irons exceeds 3.0 per cent. no pearlite, or very little, is seen; only ferrite, with coarse graphite flakes constitute the structure.

It may be stated generally that in eutectic irons when cooling down past the recalescence point Ar1, the austenite (or carburised ferrite) crystallites in the eutectic became pearlite, and at that point the last of the decomposition of the carbide takes place.

If silicon is present, more or less of the carbide in the eutectic and in the austenite or pearlite is decomposed, the final result being (cementite + pearlite + graphite); or where silicon above 3 per cent. is present, the final cooled product may have the composition (ferrite + graphite). If manganese is also pre-

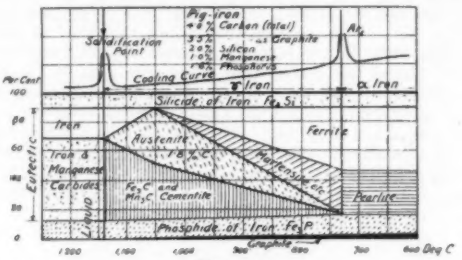


FIG. 4.

sent this exists as Mn_3C and prevents the total disappearance of combined carbon. The Ar1 point is raised by the presence of Si. alone by about 22 deg. C. for each percentage of Si., whereas when Mn. is present in irons containing 1.5 to 3.0 per cent. of Si.

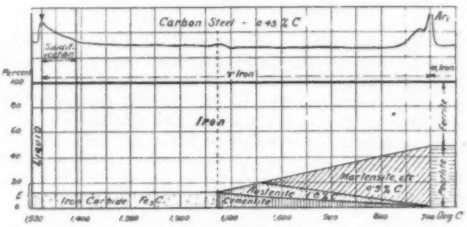


FIG. 5.

the Ar1 point is lowered by about 28 deg. C. for each percentage of Mn. (see Figs. 6 and 7).

Mr. Coe, in his Paper on "Manganese in Cast Iron," shows that Mn. alone lowers the Ar1 "pearlite" point by about 20 to 25 deg. C. for each percentage of Mn. present. Fig. 7 illustrates the influence of Mn. on pig-iron

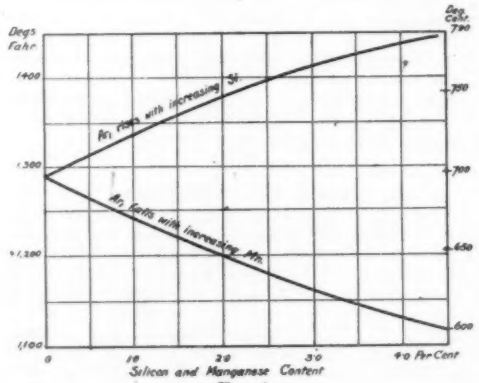


FIG 6.

containing silicon, and indicates the fact that after 0.5 per cent. Mn. the influence becomes more regular, the action of small percentages of Mn. up to 0.5 per cent. being very powerful in lowering the Ar1 point. The writer would here point out that the influence of low total carbon content in cast irons containing 1 to 3 per cent. of silicon and 0.5 to 4.0

* The diagrams in Figs. 2, 3, 4 and 5 have been constructed on the basis that all carbon-iron alloys are of the character "eutectic plus iron." Vertical ordinates at any temperature give the constituent percentages in the alloy at such temperature. The diagrams graphically illustrate the changes taking place whilst cooling from the freezing point to the pearlite point or below.

per cent. manganese is seen on the recalescence points Ar1, which are lowered by Mn. more rapidly when the total carbon is diminished. Ledebur shows this fact clearly in his "Das Roheisen," p. 67, where the

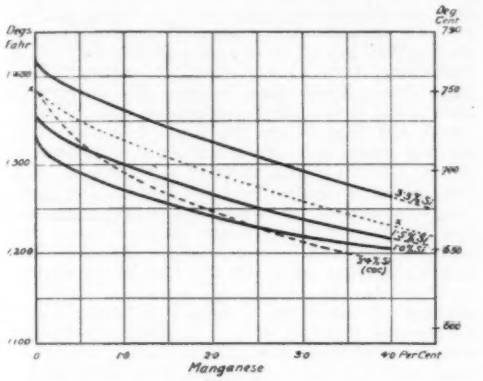


FIG. 7.

total carbon in silicon irons varies, obviously due to oxidation during melting in the air furnace. Thus he gives for a series of irons containing about 1 per cent. silicon with varying carbon content the corresponding transverse strengths as shown in Fig. 8.

Correcting for loss of carbon in the eutectic and a corresponding gain in the ferrite + iron silicide content, the writer has added the values of same, and in Fig. 8 the relation of the variables to one another is shown.

Total carbon % ..	.. 3.35	2.90	2.42	2.15	1.53
Transverse strength	.. 22.5	29.7	36.7	43.5	45.7
Eutectic %	.. 78.0	67.0	56.0	50.0	36.0
(Ferrite + Fe_3Si) %	.. 22.0	33.0	44.0	50.0	64.0

The transverse strengths increase inversely as the total carbon. This is obviously due to the increase in the proportion of the austenite crystals in the eutectic, or more correctly to the free iron more or less car-

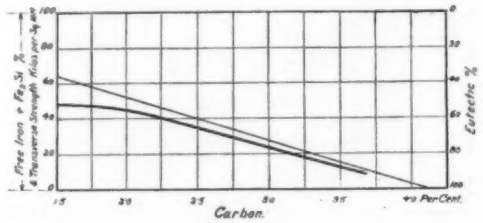


FIG. 8.

burised and finally remaining as pearlite after normal cooling down from melting point.

In this connection it should be noted that pearlite in silicon irons is intermingled with graphite (temper carbon), the more so as the Si. content approaches 3 per cent., when only traces of pearlite with coarse graphite are present. Manganese prevents the separation of temper carbon or graphite in the pearlite, and it may rationally be concluded that the carbide in the pearlite is mainly manganese carbide (Mn_3C) in cast irons containing 0.5 to 1.5 per cent. Mn. and 1.0 to 2.5 per cent. Si. The writer's researches would indicate that, providing the total combined carbon in such irons does not exceed, say, 0.5 per cent., the transverse and tensile strengths are increased by Mn. contents up to from 1.0 to 1.5 per cent. If the presence of Mn. leads to the retaining of more than 0.5 per cent. of combined carbon in the irons, brittleness and hardening result. Thus 3.23 per cent. of the Mn. in a 1 per cent. Si. iron with 3.6 per cent. of total carbon reduced the transverse strengths by 30 per cent., whereas 1.5 per cent. Mn. increased it by over 75 per cent. (an iron with 1 per cent. Si.—manganese free—being the standard for comparison).

May we not look at grey irons as 0.20 to 0.45 per cent. carbon steel embrittled by the presence of graphite, the higher carbon being due to the influence of manganese? It is worthy of note that the cooling curves of 0.45 per cent. C. steels are almost exactly the duplicates of those obtained from the two irons just considered.

It may be remarked in passing that nickel has a somewhat similar influence to silicon on the carbon in cast irons. Added to the eutectic iron (4.3 per cent. C.) the carbide is decomposed in cooling, and the carbon is thrown out of solution as graphite. This decomposition is hindered by the presence of chromium, the carbide of chromium, Cr_3C_2, being formed.

Here we have the basis of the success of nickel-chromium steels and of nickel-manganese steels of similar characteristics, when the proper equilibrium between Ni. and Cr. and Ni. and Mn. is adopted (it being recognised that the action of chromium on the carbon is much more active than manganese). Thus the writer found that on adding 5.0 per cent. of manganese to a cast iron containing 3.0 per cent. Si. this latter grey iron was converted into white, whereas the same result was obtained by adding 3 per cent. Cr. Again, a white eutectic iron 4 per cent. C. was converted into grey by the addition of 3 per cent. Si. whereas over 6 per cent. Ni. was required to produce the same result. The writer emphasises this point, because he has found in each of these alloys an equilibrium corresponding to the strongest member of the series. Thus in cast irons, 3 per cent. Si. with 1 per cent. Mn. gives a strong, tough result, whereas 3 per cent. Mn. and 1 per cent. Si. results in a weak metal

In nickel-chromium steels the proportion 4 nickel to 2 chromium gives brittle results, whereas the opposite ratio 2 nickel to 4 chromium yields a ductile steel, the carbon contents being constant.

In the present investigation silicon and manganese concern us mainly in connection with the 4.3 per cent. eutectic, which is the basis of iron and steel processes. Further light can now be thrown on the relationship between Si. and Mn. by examining a series of carbon-silicon-manganese alloys, the melting point curve of which is shown in Fig. 9. The alloy containing about 10 per cent. Si. and 20 per cent. Mn. is the eutectic of the series. It contains the alloy Fe_2Si dissolved in the (Mn_3C., Fe_3C) Fe. eutectic.

Almost exactly the composition is

$$\underset{50 \text{ per cent.}}{Fe_2Si} + \underset{50 \text{ per cent.}}{(Fe_3C.\ Mn_3C.\ Fe).}$$

This alloy is remarkably fluid and melts at 1,000 deg. C. or 130 deg. C. below the freezing point of the 4.3 per cent. carbon-iron eutectic.

It appears possible, and probable, that when the proportion 1 Si. to 2 Mn. obtains in a pig-iron the alloy (10 per cent. Si. and 20 per cent. Mn.) is virtually present in the liquid state and controls the melting point, lowering the same, and assists in giving to this alloy a fluidity which is remarkable. The alloy in question approximately corresponds to the formula Mn_2Si., but the presence of combined carbon and the undoubted evidence of carbide of manganese when the alloys contain rather more than 20 per cent. Mn., as revealed by the microscope, leads to the conclusion that it is, as stated, a mixture of Mn_3C. and Fe_2Si. in the (Fe_3C. Fe) eutectic—a kind of compound eutectic, in fact

In studying the effect of the combined presence of Si. and Mn. in steels one is led to think that possibly the above alloy affects the fluidity of such steels as contain Mn. and Si. in the proportion of 1 to 2.

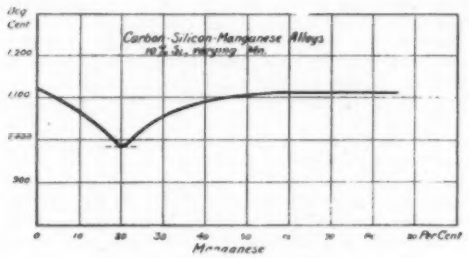


FIG. 9.

May it not be that the good effects obtained in tyre and rail steels, where the analysis approximates to 0.25 Si. and 0.5 Mn., are due to the beneficial effect of the alloy (10 per cent. Si. + 20 per cent. Mn.) during the time of solidification? Brinell has shown that such an analysis yields a sound ingot.

If commercial steels be considered as mixtures of 4.3 per cent. C. eutectic and iron, then the effect of Si. and Mn. on the eutectic portion in such steel can be studied as affecting the carbide in that portion. It would indeed appear that in the liquid state the eutectic may be actually present and analagous results accrue from the action of Si. and Mn. on the liquid carbide, to those which occur when these elements are present in cast iron. Thus in 0.43 per cent. C. steel (which may be looked up as a mixture of 10 per cent. eutectic and 90 per cent. iron) the action of 0.2 per cent. silicon would be the same as that of 2 per cent. silicon added to a white cast iron of 4.3 per cent. carbon content (the eutectic); its effect being modified by the further addition of manganese. Of course, the effects at the high melting temperatures of steel, and the high percentage of iron, will modify such action, but there is a distinct practical advantage in looking at the problem from this standpoint. Much further work needs to be done before one can presume to make any assertions on this point, so difficult is the work in connection with the actual happenings within the liquid mass at high temperatures. The writer simply throws out the suggestion that possibly some such action takes place during the nascent phases of the crystal formations.

We are thus brought face to face with the fact that all commercial pig-irons are more or less of eutectic composition, and owe their properties to this fact. They are all more or less diluted eutectic alloys containing 3 to 4¼ per cent. of carbon. There is little doubt that, when molten, the composition of such irons is not the heterogenous mass usually supposed, but that before the time of solidification, the various compounds are marshalled in predetermined order, ready for the wonderful process of selective freezing so well described by Howe. The dominant directive marshalling in all irons is that of the carbide and the iron crystallite—the companions in the descent of the blast-furnace charge. All the other elements, together with the accident of excessive temperature in the boshes and hearth, bring about changes in the normal eutectic structure which influence the final pig-iron. Varying practice in the matter of driving, hot or cold blast, classes of fuel used, and the character of the ores used, yield varying qualities of iron, and the variation in the departure of such irons from the basal eutectic is one of the most instructive and practical studies possible to the metallurgist. The writer has plotted a number of curves (see Fig. 10) showing how the various classes of pig-iron produced in different localities vary in their combined and free carbon contents, as influenced by the presence of Si., P., and Mn. The practice of high- or low-pressure blast with hot or cold temperatures, coal, coke, or charcoal, as fuel, can be traced by those who know the methods adopted in manufacture. In any case the total carbon content is below that of the eutectic and below that of the eutectic as corrected for the presence of the silicide, phosphide, and sulphide of iron. This means that excess iron is present as a result of the oxidising influence of the blast, the more noticeable when high-blast temperatures, hard driving with high-pressure blast are practised. In many irons imprisoned iron oxide is a common accompaniment of the "Bessemerising" influence, to the lasting quality-detriment of the pig-iron. One would not be surprised to find that from the same cause high nitrogen content results, as Braune has suggested.

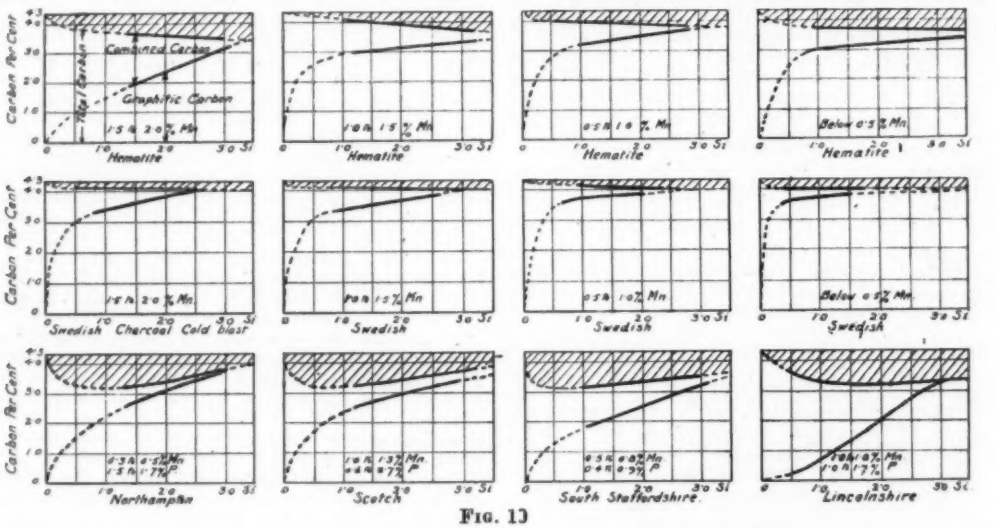


FIG. 10

Professor Turner has repeatedly pointed out that during the burning of the carbon out of cast iron more heat is evolved than if the same weight of free carbon is burnt, and it has not been sufficiently recognised that a pig-iron high in carbon content has a special value in all open-hearth processes such as puddling and Siemens steel-making, seeing that the oxidation of Si. or the silicide (Fe_2Si) is preceded by that of the carbon or carbide.

The physical composition of Swedish charcoal cold-blast iron (apart from the fact of its freedom from sulphur and phosphorus) is largely responsible for the high quality of the steel or iron resulting from its oxidation. It is initially a high-carbon eutectic iron not Bessemerised in the tuyere zone.

As every steel-melter known, its behaviour during melting and "boiling" in the Siemens furnace is very different from that even of a very pure hematite or washed iron. The difference in the final qualities of steels produced from mixtures containing hot- or cold-blast pig-irons is well known, especially if the latter are smelted in a charcoal furnace. Some of the hematite irons, however, produced in the older type of blast furnace with moderate air pressures and cool blast give excellent results.

The practical conclusion reached, therefore, after much observation and experience is that the less the eutectic iron which forms in the boshes of a blast furnace is disturbed by excess temperature and Bessemerising influences the better from the quality standpoint. The old cold-blast charcoal furnaces gave, and in Sweden give to-day, high-carbon irons low in oxide of iron inclusions and in nitrogen. Modern hard-driven high-temperature blast furnaces often give irons of quite opposite character, low in total carbon and rich in oxide of iron and nitrogen. There are evidences in many such irons that the eutectic may absorb and reject again silicon during its descent through the boshes, the rejection being brought about

FIG. 11.

by oxidation in the tuyere zone. During the exchange which takes place from the iron silicide to the silicate by such oxidation, the presence of iron oxide in the final pig-iron seems to be unavoidable.

The foundry use of pig-irons presents numerous avenues for the advantageous illustration of the "eutectic" view of the carbon-iron problem, and one is tempted to examine the questions of shrinkage, growth during repeated heatings, the use of chills and permanent moulds, in the light of our knowledge of the eutectic. The modification of the character of the eutectic due to the presence of silicon, manganese, phosphorus, and graphite leads to altered equilibria of the strains set up in the alloy structure under variations of heating and cooling. It is not conceivable that the various constituents of cast irons expand or contract together at the same rate, as microscopic examination of such irons readily proves. Fig. 11 shows how in an iron rich in manganese the carbide plates have fractured during rapid cooling, whilst Fig. 12 indicates the plasticity of the austenite

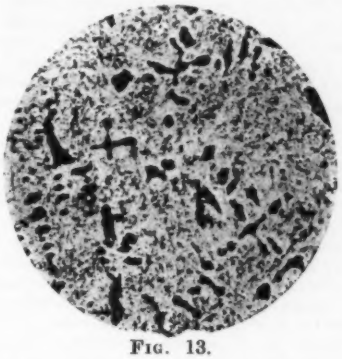


FIG. 13.

crystals just at the moment of solidification of the carbide, i.e., the material was in the "pasty" stage. Such questions present opportunities for further research.

It may be further pointed out that generally the liquid composition of cast iron may be stated thus :—

$$\text{Eutectic} + Fe_2Si. + Fe_3P. + Fe.S. + \text{Free Fe.}$$
$$\underbrace{Mn_3C.\ Fe_3C.\ Fe.}$$
$$a \quad + \quad b \quad + \quad c \quad + \quad d + \quad e$$

The eutectic portion (a) is fixed by the total carbon content 4.3 per cent. carbon, representing 100

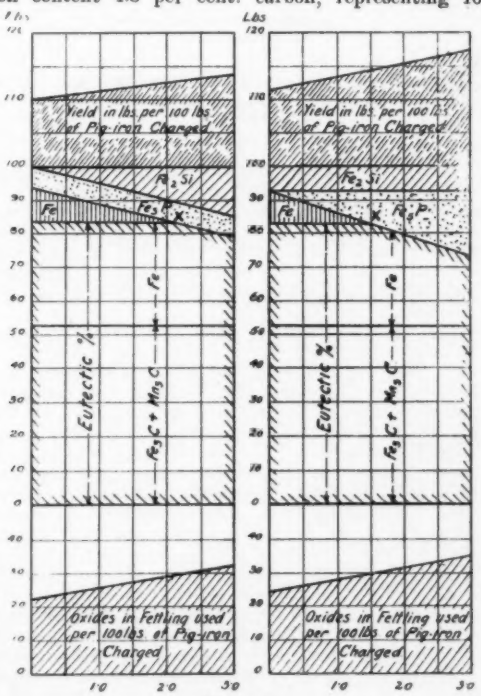


FIG. 13.

per cent. eutectic; hence for any other total carbon content C, the eutectic equivalent percentage is :—

$$\frac{C.}{4.3}\times 100. \quad a=\frac{C}{4.3}\times 100.$$

If the sum of $a+b+c+d$ exceeds 100, then there is carbon in excess of the eutectic ratio, and excess graphite is found on cooling down slowly from the freezing point. It is thus readily possible to determine whether any pig-iron will yield coarse graphite on slow cooling by applying the rules:—

$a+b+c+d$ greater than 100 = graphitic.
$a+b+c+d$ less than 100 = non-graphitic.

The diagrams, Fig. 13, illustrate the point at which, in a pig-iron containing 3.5 per cent. carbon, increasing contents of silicon and phosphorus prevent the metal from retaining more than 3.5 per cent. carbon unless the excess be present as graphite. In Fig. 13 an iron containing just over 2.0 per cent. silicon and 1 per cent. phosphorus is what may be termed "normally" carbon-saturated with 3.5 per cent. carbon. Similarly an iron containing 1.5 per cent. phosphorus and 1.5 per cent. silicon and 3.5 per cent. carbon is "normally" saturated. Points X X, where the Fe_2P. lines cut the eutectic line, indicate the point of saturation.

The writer is aware that Gontermann has favoured the theory that silicon is present in carbon-iron-silicon alloys as Fe.Si. and though probably this does occur in alloys containing more than 18 per cent. or 20 per cent. of silicon, experiments lead the writer to believe that in low-silicon iron-carbon alloys (below 10 per cent. of silicon) the silicon is present as $Fe_2Si.$, thus conforming with Guertler and Tammann's results. The presence of carbon in the above iron-silicon alloys was found to lower considerably the freezing-point temperatures, the complete freezing-point curve being, however, similar to the one published by Guertler and Tammann.

Notes on Heat Treatment of Cast Iron.

Before the Halifax Branch of the British Foundrymen's Association on March 28, Mr. R. Carrick, of Shipley, lectured on the heat-treatment of cast iron, discussing some methods employed in the treatment of other metals and alloys, the effect of heat-treatment on test bars, the condition of the carbon before and after treatment, and the advantage of such treatment, etc.

Mr. Carrick stated at the outset that the various mixings which had been used in the different test bars were for test purposes only and were not irons he would use for castings of the same thickness as the test bars shown. In a Paper he had read at Manchester in November, 1912, on "Chills to overcome Liquid Contraction,"* he had drawn attention to the term "chill" as it was commonly used, and said this was a misnomer, and conveyed a totally erroneous idea. He, along with others, thought some other term should be adopted. In the January issue of the FOUNDRY TRADE JOURNAL, following his Paper at Manchester, the editor took up this question and suggested the use of the word "densener." This appeared to him to be the most expressive term yet suggested, and it was the term he should use through the present Paper in the place of the word "chill."

As to what was meant by the term "heat-treatment," most foundrymen were fully aware of its significance as applied generally to metals and alloys:—The annealing of steel and malleable castings after they had been moulded and cast; the case-hardening of tool steels for spindles, gears, etc.; the tempering of hardened steels, or the annealing of ordinary small castings as carried out in foundries doing textile machinery. It was not this form of treatment to which he intended to refer, but the heat-treatment of cast iron after it was poured into the mould, while it was being transformed from the liquid to the solid state. A very able article on this subject had appeared in the September, 1913, FOUNDRY TRADE JOURNAL, by D. Whitelaw, in which the term "primary" heat-treatment was suggested, whilst the other methods should be known as the "secondary" heat-treatment; "primary" should be applied collectively to those conditions brought about by melting, casting, solidification, and the cooling subsequent to the solidification of a metal or alloy.

He (Mr. Carrick) thought that was a very comprehensive definition, and put the whole thing very clearly. Practically all the forms of heat-treatment mentioned a moment ago, such as were used on malleable cast iron, steel, wrought iron, and all iron-carbon alloys, had as their main object the changing of the carbon in some form or other. But the methods of heat-treatment he wished to speak of were entirely different to those just cited, though they had exactly the same end in view, *i.e.*, to get the carbon in the correct condition in order to have the finished casting perfectly solid, homogeneous and of the maximum strength. It was universally believed that the carbon and all the other metalloids in cast iron were in combination with or dissolved in the molten metal coming from the cupola, and that they only came out of combination while the metal changed from the liquid to the solid state. Whatever might be the composition of the iron charged in the cupola, whether hot blast or cold blast were used, high silicon or low silicon, or whatever the chemical analysis might be, the length of time taken for the transformation of the iron from the liquid to the solid state would be as important a factor in controlling the physical quality of the iron, as would be the original mixing of it; and it was equally important to pay attention to that change as to the correct mixing of the metal.

In recent years much stress had been laid on chemical analysis. Chemical analysis was not the only controlling factor in the determination of the physical quality of a casting. As illustrating this he mentioned a case where large quantities of castings were made, in which there were great variations in thickness, some sections being only $\frac{3}{16}$ in., while other sections were from 2 in. to 3 in. The thin sections had to be sufficiently soft to enable them to be machined with expensive milling cutters, and at the same time it was essential to have the thick sections free from porosity or sponginess. Now to get a casting $\frac{3}{16}$ in. or $\frac{1}{4}$ in. thick sufficiently soft for machinery purposes, the silicon should not be less than 2.40 per cent., and the total carbon not less than 3½ per cent., but that was totally unsuitable for a casting 2 in. to 3 in. thick; a casting that thickness and with that chemical analysis and cooled normally, would give a weak, open-grained structure. It was here where the value of heat-treatment was seen. Denseners were inserted at the thick sections, and assisted in rapidly converting the metal from the liquid to the solid state, and these sections were equally as solid and strong, in fact, stronger and better than if they had been cast in a low-silicon, low-total-carbon iron, and cooled normally without the denseners.

The lecturer here exhibited slides showing the effect of denseners on test bars 3 in. by 3 in. by 6 in.

* See FOUNDRY TRADE JOURNAL January, 1913.

"A and B" were cast at the same time, out of a ladle of metal with the following analysis:—2.30 per cent. silicon, 1.15 per cent. phosphorus, 0.10 per cent. sulphur, 0.50 per cent. manganese. Four denseners 1½ in. thick were placed on the sides of "B," and approximately 1½ minutes elapsed from the time it was cast to the time it solidified. "A" was cast in a sand mould and took approximately 8 minutes to solidify. The fracture of "B" showed a far more dense and homogeneous structure. Another test bar "C" of the same dimensions, the analysis of which showed 1.25 per cent. silicon, and 3.10 per cent. total carbon, had a structure much closer than "A," though not anything like so dense as "B." Other slides exhibited showed how, by prolonging the rate of cooling, test bars had been made actually more open in structure than the pig-iron from which they were cast.

The lecturer said that many times he had found it easier to get a perfectly solid and homogenous casting by the use of iron moulds or denseners, with an iron containing, say, 2.50 per cent. silicon, than could be obtained with an iron very low in silicon and without the use of denseners. He did not here wish it to be understood that he was recommending fresh mixtures; he was dealing with castings which had thick and thin parts. He next showed a series of transverse tests taken from bars cast without denseners, and which had shown an average increase in strength of 250 lbs. through the use of denseners. These tests were in accordance with Mr. F. J. Cook's tensile tests, in which a tough mixture cooled normally showed a strength of 11.6 tons per sq. in., while with a soft mixture and the use of denseners the tests went up as high as 16.2 tons per sq. in. When denseners were employed they should be removed from the casting at the correct time. If this was done the metal would be machinable and would be no harder than iron that was commonly used for engine parts, such as cylinders, liners, or hydraulic cylinders. Of course, if the denseners were left on too long until chill set in (and the word "chill" was used here in its proper sense, and implying a white iron), then, of course, machining would be almost impossible. A slide was here shown of a casting similar to the others, cast in the same way, two of the sides having denseners; as soon as the metal had solidified one densener was removed and the other left on, and there was a distinct chill where the densener was left on. Hardness tests were made on this casting by means of a Brinell hardness-testing machine, which gave the following depressions:—Chilled face, 37 m/m; with densener, 40 m/m.; ordinary, 42 m/m. The side on which the densener was left was too hard to machine, whilst the side from which it was removed at solidification was machinable.

The foregoing, continued Mr. Carrick, led to the conclusion that whilst the length of time taken in the transformation from the liquid to the solid was mainly responsible for the solidity of the metal, the ultimate degree of hardness was largely governed by the length of time in cooling after solidification had taken place. A very simple experiment would make this clear. A casting plunged into water immediately it had solidified would be extremely hard, even if it were of a thick section and had solidified very slowly. A noted American writer stated that he had "proved beyond doubt that molten cast iron did not *chill* until after the casting had set." Mr. Whitelaw, on the other hand, came to the conclusion that chilling depended on the rate of cooling through different ranges of temperature, and gave one or two instances where rapid cooling at one temperature produced no chill, whilst rapid cooling at a higher temperature produced a chill ⅛ in. deep into the casting, all other conditions being the same. This at first sight would appear to destroy the theory that molten iron did not chill after the casting had set. On closer examination it would be found that another important factor, viz., the conductivity of the mould was involved. The high-temperature metal had the effect of raising the temperature of the mould very considerably, without giving up sufficient heat to come down to the chilling temperature limit; consequently a slightly lower rate of cooling would be got after the metal had set than in a casting where the mould had not been raised to so high a temperature.

The lecturer then showed the results of six successive transverse tests on the standard 1 in. sq. bar on 12 in. centres. Two bars were cast in a box, one bar having a number of denseners 7/16 in. thick placed on either side, whilst the other was cast ordinarily. The denseners were removed as soon as the casting was set. In each case the rapidly-cooled bars were the strongest and most of them gave results better than would have been obtained with a good cylinder iron. The lecturer then asked what was the explanation for this improved quickly-cooled iron? If it was a fact that all the carbon in molten iron was in the combined form (and there appeared to be little doubt about it), and if it were instantly cooled to, say, 1,000 deg. F. (that is to solid), then the bulk of the carbon would still be in the combined form, but, cooling normally after that, it would change to the free form, not altogether graphite, but more after the nature of annealing carbon in a very finely divided state, and there was very little doubt that it was this condition of the carbon that gave these castings their unusual strength and solidity.

Discussion.

Mr. A. Brearley asked the lecturer what he would do when denseners were so placed that they could not be removed just at the time of solidification of the metal.

The Lecturer replied that in a case like that the denseners were left in.

Asked by Mr. Stacey if there would be any difference in the tests of iron cast in green sand and dry sand, Mr. Carrick said there would be a slight difference, as those cast in green sand would cool more rapidly.

Mr. Berry said it was 14 years since he saw the first densener used. He saw possibilities for the further development of this class of work. They had used them on both pulleys and faceplates, but did not get such good results with the pulleys as with the faceplates. Where the work covered a large range with a great variety of thicknesses of castings, and not many irons to work from, the use of denseners seemed to be the only practical way of obtaining satisfactory results.

Mr. Love said that denseners and even chills were useful in their places. He had known cast iron to be so hard that cutters were made from it to machine hard steel. Denseners required thoughtful application. There had been some talk of requiring high tests; his advice was the use of 25 per cent. of steel.

Mr. Carrick, replying, said that in Halifax Mr. Robinson showed some remarkably high tests, and if a man understood the mixing of metals and knew his cupola he could get tests as high (which had, he understood, reached 20 tons tensile), without the use of steel.

A hearty vote of thanks to Mr. Carrick concluded the meeting.

Modern Steel Foundry Practice.*

By J. Peers.

This subject may be considered from many points of view, but the writer proposes to deal chiefly with the general principles involved in the manufacture of steel castings made in sand moulds. Steel-founding is essentially an art that can only be acquired by long experience, and as there are so many small details to contend with, it is only possible to give a brief survey in the present Paper.

Preparation of Sands.

First to be considered is the preparation of sands. The colour of a sand is no guide to its quality, and care should be taken that no substance is present that will destroy the good effects of the mass, as can be very easily done. Very often the sands as brought direct from the quarry are mixed up, according to size and shape of the castings. In many instances all new sand is used, but this is a great mistake, because the uniform treatment of moulding and core sands has a great influence on the quality of the castings, and much material might be saved and a better product obtained.

To prepare moulding sands for green-sand moulding, the new sand from the quarry or sand-pit should be dried (not burnt) to remove the bad effects of organic matter and also to destroy the hydrated crystals very prevalent in the silicates of lime, felspars, and silicates of alumina. The nascent hydrogen arising from the water crystals in the sand as brought from the quarry is very detrimental, and if the sand is used in the raw state, as is the case in many foundries, the steel will not run up sharp in the moulds and also the castings will be pitted with small blowholes.

It is also important to remember that after the sand has received a good treatment the floor sand may be made too wet, which will nullify to a great extent the benefits that should be derived from the good properties of the facing sand. A mould is like a vessel to hold gases; therefore, the drier the floor sand the easier will the gases penetrate. Dampness is the worst enemy to steel-moulding, as it is in all green-sand moulding. If the gases in the mould cannot penetrate the walls of the mould they are taken up by the metal, causing either blowholes or scabs on the face of the castings.

The mixing of sands after drying can be regulated, and many firms that are paying good prices for sand very probably have a sand-pit close at hand, and by fixing up a drying plant, these sands could be utilised by using a binder similar to the following:—Add to 4 lbs. of raw linseed oil nine gallons of water and boil gently for two hours; then when cool, mix it with the sand. This forms a good and a cheap binder, and will save having to pay expensively for sands that have a reputation by reason of a vegetable oil deposit in the sands.

It might here be mentioned that a binder of the above description will also be very beneficial for malleable cast-iron work. Very often castings after annealing are not much better than before annealing, and in many instances no better. This may result from the moulder being allowed to use his own judgment with regard to the mixing of sands to suit his own particular job. Too much coal dust is added to secure a clean face on the casting, and this excess of coal dust forms a superficial skin of magnetic oxide (Fe_3O_4) which prevents the annealing of the casting. By drying the raw sands and using a binder similar to the one given, coal dust can be practically done away with, and therefore this magnetic oxide of iron is not formed; also, as many malleable-iron castings have to be tinned, it will allow of the tinning being done much better. It has been put forward that coal dust helps the venting, but what coal dust actually does is to carry away the moisture through the vents, and if more coal dust is used than is necessary, or if the venting is too little, the castings will be seamed by the extra gases set up. The gases set up by the method advocated are practically nil, and the oil gives a clean face to the castings. The moulder is able to ram his moulds much harder than formerly; this would be bad practice with ordinary green-sand work, because to ram hard on the face of green sand moulds would be to court danger under ordinary conditions. It has been the moulder's sense of touch, his knowledge how to ram, that has enabled him to make his mould just solid enough to withstand the pressure of metal and not too hard to form scabs.

To renovate old and burnt sand, common clay should be dried in the drying plant and then mixed with the old sand or burnt sand, one shovelful (if very badly burnt, two shovelfuls) to a barrow, mixed in the dry state and tempered down with water—this also saves time with regard to mixing clay-wash to temper down the sand in dry-sand work. The drying of these sands does not affect the refractory nature of the sand, and although it is difficult to drive off the water crystals in the felspars, yet most of the gas-producing elements in the sand are destroyed.

Green-sand moulds do not offer the same resistance to the shrinkage of steel castings as do dry-sand moulds. In the case of small castings made in dry sand, no doubt one of the greatest drawbacks is the trouble due to the hot cracks, on account of the moulds being too rigid.

The cost of putting down a drying plant and the extra treatment of the sands is recompensed by the saving in the drying of moulds and the labour in placing in and out of stoves, reduced fuel costs, and less liability to any flash of metal, which is one of the greatest evils on a steel casting. There can be no doubt that steel castings made on these lines will come more to the front more than formerly. There is no waiting seven or eight days in annealing. Should the mould become fractured through any cause, the sand may be damped to allow the moulder to mend up the fractured part; this dampness can be driven off by a blow-lamp, and the blow-lamp will not destroy the water in the crystallised state. No matter how efficient the venting in a green-sand mould, if the sand is dense or too damp, the castings will not come out solid; therefore to make good moulds and cores it is essential to make good material of the right quality the first consideration.

Dry-Sand Moulding.

In dry-sand moulding the sand is required stronger, because it is for much heavier work, but even in this class of moulding the sand should be regulated. In dry-sand work for steel, where any

* Paper read before the Sheffield Branch of the British Foundrymen's Association. Mr. Thomas Firth in the Chair.

spaces occur blocks of wood are rammed up in these spaces, so that the mould will have a better chance of yielding as the steel cools down to atmospheric temperatures. To prevent the face of the mould from cracking, which is often the cause of a waster, after drawing out these blocks the face of the spaces should be cut up with the trowel to allow the escape of gases and the spaces filled with cinders and dry sand after the mould is dried. Also, when the moulder has put cinders round the pattern, instead of making a hole from the underside in the plate to the cinders, pegs should be rammed up (see Fig. 1) from the cinders to the joint of the mould, and the vent carried from the

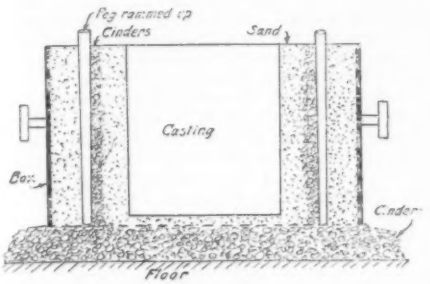


FIG. 1.

joint through the top part of mould, in continuation. The same applies to the cores. This will largely prevent sponginess in the upper part of the casting, because the gases have a free exit, and also during the drying process the moulds have a far better chance of thoroughly drying. Many moulds are only half dried as the result of not finding facilities for the escape of steam generated. It very often happens when ramming-up in dry sand, that there is not room to put cinders in some particular part that will require easing; therefore, when ramming up, wet parting should be put in between the facing sands or compo. This will yield better than all facing sands or compo. and will also help when easing, it being far easier to remove than a hard substance—in fact, if it gets an opening it will fall out of its own accord.

Compo is often wasted, and should be used according to thickness of casting. It is not waste to put a little extra to a thicker section of the casting, but to put 3 in. of compo. to a casting 1 in. sectional thickness is wasteful, when a thickness of 1½ in. compo. would be quite ample. When making moulds in compo. and cut nails are placed in the face of the mould, care should be taken that the hammer head does not leave an impression, because this forms a joint, and the paint will strip off, causing an unseemly mark on the casting, and leaving the dirt in the casting, perhaps in a vital part. Moulders after drawing a pattern will often sprinkle the compo. with water, which is readily taken up by the fireclay in the compo, with the result that the face of the mould is made very dense, and when the paint is applied, instead of the mould absorbing the paint, it forms a joint, and is liable to cake off when the steel enters the mould. It is far better to use a flat board or cork to do as much finishing as possible without sprinkling with water; this leaves the mould porous. If compo. has been left in the shop and becomes dry it should be taken back to the mill and mixed up again; to use water on prepared compo. or sands is wrong, and does not produce the best castings.

Cores.

Cores should in all cases yield as much as possible with safety; many wasters are caused by cores being too rigid or under-dried, and it is bad practice to wet them too much. In one instance a core was put to dry on the Saturday, but only the outside portion of the core dried, leaving the inner part damp, and later the fire was re-lit and the core thoroughly dried; but when brought out of the stove large pieces fell away, exactly as though there were joints, owing to the part that had dried first expanding and forming these joints.

Another point to remember is that if cores of any considerable size made from a damp sand are placed in the stove straight away, they will expand considerably, but if allowed to stand in the shop for a day before being placed in the stove, will come out exactly to size. Cores for manganese steel are so friable that if a chaplet or stud is used to hold them up the chaplet or stud will force its way into the core, and to obviate this the coremaker should place wire nails about 1 in. apart on that part of the core where it is known the stud will come.

When a flaw occurs because the core has not yielded enough, moulders often resort to the use of brackets or tying pieces. These brackets may save the casting, but it would be much sounder if the cores were seen to thoroughly. When core irons have to be used, it is far better to bend them than to use straight irons. If core grids are used, two small pieces of wood should be placed between the extreme ends of the core iron and the core box; these pieces of wood become charred when the core is drying, and just give enough to ease the casting until the core iron can be removed.

Pattern-Making.

When the pattern-maker is well up in actual moulding details, much of the trouble of the moulder is saved, because he does not follow the draughtsman in every detail. The pattern-maker can learn much from the foundry; to allow enough draft for the pattern to be drawn; how a core print should be formed, not in order to make it easier for the moulder, but to prevent the rubbing of cores. In steel moulding, cores are very prevalent, and the pattern-maker should have a thorough knowledge when making core boxes, so that the vents will coincide; this very often causes a lot of unnecessary work when assembling the cores, as often vents have to be stopped up and fresh ones found.

For green-sand moulding, patterns should be well made, all filleting and rounding of corners being done on the pattern. It is far better to have as little to do at a mould as possible, especially in the class of green-sand advocated; but this also applies to all moulds, the simpler the design of the pattern the quicker the moulder can make his mould and the better the casting. It may be that by a loose piece, or perhaps a core, hours of work on a job can be saved.

Moulding Boxes.

Boxes for steel moulding have in many ways to be made different from boxes of cast iron. Spaces should be left in the boxes, so that it is possible to get inside the box with some tool, either a shovel or a rake. For example, a gun shield (Fig. 2) made in a box has two or three spaces left in the side of the box, from 12 to 15 in. deep and about 11 in. wide; a slate placed across these spaces and rammed up in the usual way allows the slates to be broken by bars, the easing being done without disturbing the casting and much quicker. For some jobs standard boxes are made to suit, but for heavy jobbing work sets of interchangeable boxes should be made in segments

bolted together. If the cases are made of different depths the moulder will be able to make a much safer job; also the sides of the box can be unbolted and taken off for easing purposes.

It might be well to mention here a method used in loam moulding, which saves a large amount of

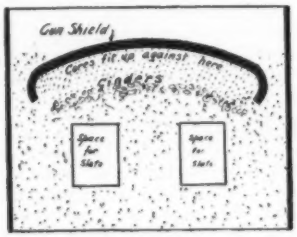


FIG. 2.

labour in digging out holes and placing moulds in a pit, also the trouble of ramming round the moulds. When making the plate to carry the outside part, if of 4 ft. diameter, four holes are put in the plate similar to Fig. 3; if of 6 ft. diameter, six holes. Bars are cast to fit in the dovetailed holes, and each plate that follows when building up is made with holes to correspond and wedged tight to keep them in position. The building up of the mould is carried around these bars, and when ready to cast, two or three lengths of chains are run round the job and wedged, which holds the job secure.

Feeding and Gating.

This is a very important part of the moulder's work, and requires no small amount of forethought on account of the narrow range of fluidity in steel. This often causes many foremen to advocate too large an in-gate, which invariably means a great source of danger, and also a waste of metal. When pouring care should be taken that the down-runner is not choked at the commencement; where iron bushes are used this makes a lot of work cleaning them. For small castings bushes made from sand and dried, similar to a core, obviate this cleaning of the bushes. If a careful study is made of the pressure that can

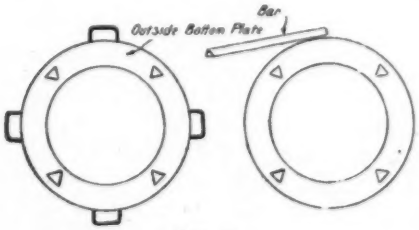


FIG. 3.

be applied by raising the height of the runner basin in comparison to risers, this will allow of a good deal less runner area.

When casting a mould of, say, 6 ft. long and of about 6 cwts., a shank of hot steel poured in from the other end soon after commencing pouring will cause the steel to run up sharp and also prevent the casting from pulling, which would certainly occur if run from one end. It is possible to help the feeding by placing certain boxes at a gradient on a good many jobs.

When making a casting of circular design, the in-gate or in-gates should be placed at a tangent, so that no resistance is offered to the flow of steel, as would be the case if a straight in-gate was used. This applies whether from the inside or outside of the casting, but the writer prefers the runners from the inside whenever possible, because less resistance is offered to the casting when cooling down to atmospheric temperature. When castings are of a large size, silica blocks with holes of various sizes to suit the particular casting may be rammed up with a down runner rammed up behind. The silica block forms the ingate; it is made much easier, is cleaner, and resists the heat better than sand or compo.

If running moulds from the centre to prevent slag inclusions, a bush with a good basin, and a hole or holes to suit according to size of casting, should be used. This will keep the castings clean, and these bushes can be used over again a good many times. The feeders on all castings should never be on the small side, and where the feeders join the casting as much area as possible should be taken up. Chills are used extensively in steel and are very effective, but the fact should never be lost sight of that the head metal should not be decreased. There are various devices used to secure solid castings, but these have to be used according to the job, and it would be of little use to advocate any hard and fast rule.

Shape and Form of Test Pieces.

The part of the casting where test pieces are cast on should be noted carefully, because a considerable influence on the ultimate strength may be brought about by good judgment. It is often the case that the test pieces do not give a true record of the value of the castings. The occurrence of cavities, slag inclusions, and dirt in test pieces leads to erratic results, and these difficulties have to be met by the moulder's craft. Taking the example of a casting of a sectional thickness $\frac{5}{8}$ in., and on which a test piece is required 9 in. by 3 in. by $1\frac{1}{4}$ in.; on cooling down the casting will rob the test piece, and while the casting may be all that is desired, yet the test piece may give both a poor tensile and a poor impact test. To obviate this, the test piece is chamfered down to $\frac{3}{4}$ in. or $\frac{1}{2}$ in. where it joins the casting. It may be that the sand will not always keep up the sharp edge if of a friable nature, and in this case strips of core should be rammed up with the test piece, to keep the notch in a true form.

The Effect of Treatment.

Castings of small or medium size can be taken out of the moulds as soon as they have solidified. This prevents them being too long in cooling, and restricts the growth of crystals of a relatively coarse grain, which cause weakness. The smaller the crystals the greater the tenacity of the castings. This removal of the castings from the moulds also facilitates the castings stripping much easier.

The effect of heat treatment of manganese-steel castings is very noticeable, and the change from austenite to martensite is a very quick one. If such steel is allowed to cool slowly in the mould, it will be wholly, or practically wholly, in the martensite condition. That is to say, at atmospheric condition with 15 per cent. manganese, the casting is self-hardened. To get the best results from quenching the castings should be allowed to cool down and be then re-heated to approximately 1,000 deg. C., but for castings of an intricate design it is possible by having a tank of water handy in the shop to allow the casting to solidify sufficiently in the mould, and then drop the casting into the tank. This many times saves a casting that would otherwise always show a fracture.

The chief point in casting manganese steel is to have the ferro-manganese thoroughly melted. There is often a marked difference of opinion as to whether alloys should be poured into the vessel or bath, or whether they should be poured into the ladle. If the alloys are well melted and poured into the ladle at the same time as the steel, much less alloy is needed to gain the same effect, because by pouring the alloy into the bath some portion is taken up with the slag. If the ferro-manganese or ferro-silicon is added to the bath, anything from 12 to 15 per cent. extra loss of the alloy may be incurred. The same applies to nickel; if it is not properly melted it will instead of making a good alloy form shots all over the casting.

Foundry Lay-Out.

For an up-to-date foundry, a compressed-air plant is a necessity. This enables the installation of pneumatic rammers and jar-ramming machines. The moulds do not require so much brushing after drying, which very often spoils the face of the mould; the cleaning out of small accumulations of sand is easier because a nozzle with a flexible pipe can be attached and moulds can be blown out quite clean after all cores are assembled.

For general work the best form of machine, and the most economical, is the home-made stripping machine, which can be made to carry a plate of a certain size; but different sized castings can be made from the same machine. If the castings are of an intricate design, plates can be cast to come within a short space of the pattern, the pattern fixed on the carrier. Asbestos or clay is packed between the stripping plate and pattern, and after carefully filling up the space a mixture of 4 parts antimony and 24 parts lead may be melted on a blacksmith's forge (breaking up the antimony in small pieces to mix with the lead) and poured in. This alloy allows the pattern to work freely without marking it, and also has the peculiarity of coming out, if cast in sand moulds, exactly to size of pattern.

An important item which is conducive to good results is the heating of ladles and shanks. These should be arranged on a hearth so that each one before coming under the converter is heated to practically a white heat; this can be easily done by the aid of a blast similar to the blacksmith's forge, only longer, and as a ladle comes back from casting it should be doctored up as required and placed back on the hearth, a fresh ladle being ready heated to take its place.

For general engineering work and motor engineering castings, the converter process has a great advantage on account of its adaptability, although for large castings the acid open-hearth process is worked at a lower cost, but against this all the steel has to be tapped at once and the foundry space is taken up more than with the converter. In the case of small and intricate castings, the temperature of the steel must be high to allow the castings to run up sharp. The Tropenas converter is capable of burning the carbon to carbon-dioxide, $C+2O=CO_2$, giving 97,280 calories; in the acid open-hearth furnace the carbon is only burned to carbon monoxide, $C+O=CO$, 29,160 calories. Therefore for good general work and small castings, the converter has the pull, and if larger work is taken in, two or three converters can work in conjunction.

With the Tropenas there are two distinct drops of the flame and it is possible for the blower to humour the temperature to suit the work to be cast. To shorten the blow as much slag as possible should be kept in the vessel. To make good steel castings, whether Mn., Ni., or other alloyed steel, to get the best results the alloy should be thoroughly melted.

Discussion.

Dr. W. H. Hatfield observed that he did not altogether agree with the lecturer on the question of small steel castings not requiring to be annealed. If a small steel casting were examined under the microscope it would be found that owing to the extremely high temperature at which it was cast there was a distinct lack of homogeneity, and it was really essential that it should be annealed. As to the time lost by annealing, he thought that was exaggerated. Referring to the suggestion made by Mr. Peers that the appearance given by coal dust to the casting was due to the formation of magnetic oxide of iron, he said he thought if Mr. Peers went further into the matter he would find it was not due to magnetic oxide; it was more a direct result of the presence of carbonaceous matter.

Mr. H. Brearley said he thought Mr. Peers hit the right point when he emphasised the necessity of attention being paid to the matter of moulding sands, particularly in regard to the preparation of the sands. He believed that generally the ideal sand would consist of grains of uniform size, but it would not matter what that size was if they held together with a sufficient amount of strength. Nobody, however, produced a sand of that particular kind. He had frequently heard Sheffield moulders discuss the question as to whether it was the proper thing to take out the dust from the sand either by blowing or riddling, and some contended one thing and some the other. In so far as the dust interfered with the permeability to the gases that were formed inside the mould, it would be better to have it out of the way; but as the dust contained probably most of the plastic constituents of moulding sand, its removal might have some unlooked-for and undesirable effect. He could not agree with Mr. Peers when he said they should take castings out of the sand in order to allow them to cool quickly. It was not worth while doing that in order to prevent the formation of large crystals. The formation of large crystals did not increase the difficulty of annealing steel castings. Even very large steel castings, weighing many tons and having crystals as large, perhaps, as ⅛ths of an inch across them, would break down in the annealing operation very quickly indeed when the proper annealing temperature had been reached. As an illustration of this fact, Mr. Brearley referred to an article in the Foundry Trade Journal of December last.

Dr. T. Swinden said Mr. Peers had laid considerable stress on the necessity of having alloys well melted. He (Dr. Swinden) presumed that meant melted before being added to the steel, not melted in the steel. Mr. Peers had mentioned a loss of 12 to 15 per cent. of ferro-manganese through adding it to the molten bath, but he (the speaker) thought that was very low indeed.

Mr. Stobie said he had known cases of low-carbon steel castings—perhaps 0.15 carbon—which required no annealing at all, and the fact that they were in a properly crystallised condition was evidenced by their being able to hammer them flat without any annealing being done. In those castings the sulphur was exceedingly low, and probably better diffused than in small Bessemer-converted castings.

Mr. Peers, replying to the discussion, said that if the dust were removed from the moulding sand, then some binder was used to recover the plastic nature of the sand. As to the point raised by Dr. Swinden regarding the small loss in alloys, he ought to explain that he was talking of a converter. The point was that by putting the alloy in the bath, an extra 12 to 15 or perhaps 20 per cent. of the alloy was lost in the slag.

The Foundry Chemist.

At a meeting of the Lancashire Branch of the British Foundrymen's Association, held at the Manchester Municipal School of Technology, on March 7, Mr. Alfred Harrison, of Castleton, read a Paper on "The Foundry Chemist." An abstract of the Paper follows:—

The application of chemistry and its sister science, physics, to the materials and methods of the moulding shop, has taken definate shape only within the last 35 years, and in still more recent years has it been considered necessary by most founders to resort to the chemist to learn something of the constitution of the materials used in founding. But, to-day, without the aid of applied science, grey-iron founding would be in the position of a petrol motor without petrol—it would be at rest, and so stagnate. Let us take the production of pig-iron as being perhaps the most important to the trade. In this production the chemist, perhaps, plays a bigger part than at any other stage, for it is the chemist who calculates the charges to the blast furnace, regulates the fuel proportion and the amount of fluxes, and, indirectly (perhaps now directly), grades the pigs into numbers, from which the founder has been and is now in the habit of choosing the materials most suited to his needs, irrespective of the composition of that particular class of pig, so long as it bears or is called by the number that, from his experience, he believes he needs.

At this point I might differentiate between the chemist and the analyst. The latter, a very necessary individual, is simply one who analyses, and, of course, passes on his results to someone who can make use of them—be he manager or anyone in charge of the foundry, even a chemist. The chemist is one who, from his special training, should, from analyses made by or supplied to him, gain information to help him to regulate his materials, and so apply his scientific knowledge to the practical side—in short, a scientifically-trained practical man.

Let us now come to direct reasons for the existence of the foundry chemist. We will take the materials used in the order of their importance, and, of course, first on this long list is the pig-iron. As mentioned, it is customary to grade pig-irons by numbering them from No. 1 upwards, to, say, No. 6, forge, etc., irrespective of the relation of one maker's No. 1 to any other maker's No. 1. The appearance of the fracture of a pig of iron is considered sufficient indication as to the nature of that pig, though why this should be is always a puzzle to me, for it must be and is generally known that fracture does not depend upon constitution alone. Yet in the mind of a foundryman buying iron there is the idea in his mind of, say, a No. 3 with so much silicon—it usually ends at silicon—and yet it is also common knowledge that one maker's No. 3 may be similar in composition, etc., to another maker's No. 2 or even No. 1, and also that, say, a No. 3 this month is very different from a No. 3 next month from the same furnace, and yet no notice of the alteration will be conveyed to the purchaser. I have in mind at the moment a pig-iron offered as No. 1, and yet on analysis it contained but 1.25 silicon, whilst at another time the same brand would have contained as much as 4.0 per cent. Si. I am aware that the question of grading by fracture or otherwise opens up issues that cannot be settled by any body of foundrymen, but can only be met and correctly based by the agreement between foundrymen and the pig-iron makers; but as at present this does not seem likely to accrue, I take it that the solution lies in the using of the different numbers by knowing their composition by analysis. The waste castings that might be saved by a correct knowledge of the composition of the iron might easily cost much more than very many analyses.

Take, for instance, the five samples of pig-iron here exhibited. Is there any foundryman who would care to decide from the fracture which of these would produce the softest or the hardest castings, either alone or mixed with other pig-irons or scrap? They are marked 1, 2, 3, 4 and 5, and their composition, save for very slight variation in the P. and Mn., is the same. Yet two of them are No. 4, two No. 3, and one a soft Scotch.

It takes a very good observer—or guesser—to judge of the nature of a pig from the fracture alone, and this is where the chemist helps by adding his knowledge of the chemical composition to that of the man who judges by appearance alone.

It is claimed by many that certain brands have properties—inherent and peculiar to themselves—not in any way due to the composition or their after-treatment. If this be admitted—then to quote one writer—"the foundryman is at the mercy of the pig-iron maker, and the blast furnace fairly owns the foundry," and it shuts out the foundry from the market when the prices are much lower. The chemist should be of great use to the buyer of iron, in fact, should have the buying—or at least have the naming—of the brands required; for it often happens that the highest priced iron is not the best for the work for which it has been bought, and it is possible to substitute a low-priced for a high-priced iron and get as good if not better results. Of course, the chemist is of most value to the maker of special castings, where it is so necessary to carefully balance the different elements in the mixture. The foundry chemist who is worthy of the name will not claim to be the sole arbiter in the science of the production of castings, but he will claim that by his aid, much that might be wrong could be put right at the beginning.

An American description of a good chemist is:—"A man with springs in his heels, who will apply his knowledge of chemistry and physics and other subjects in every way possible. He should have the run of the works, and above all, he should have responsibility thrown on him, which will give him a chance to show his knowledge and resourcefulness."

It is not many years since eminent writers on foundry matters condemned absolutely the use of any form of steel in the cupola with the pig-iron, and claimed that it could not be melted, and if it did melt it would bung up the tapping hole, and so the cupola. Yet to-day it is common practice to use up to 50 per cent. of steel scrap, and with excellent results. (I may say that 14 years ago I melted in the cupola in my charge all the steel and iron scrap I could get, and often used up to 35 per cent. without ever having trouble, save with the foreman, and the results were good. Amongst this scrap was much galvanised iron which, according to the text books of 20 years ago, should not on any account be melted in the cupola, as it was said to lower the heat of the cupola and so stop melting.)

Generally speaking, we may assume that irons with similar compositions have similar physical properties, so that we may conclude that physical properties depend upon composition; but such properties also depened upon conditions of melting, casting and cooling, so that any success in the use of the chemical

composition must depend upon the conditions and, of course, upon the chemist's capability.

The principal qualities of a good iron are fluidity and cleanliness—the latter including what is known as "life," and these properties depend entirely upon the chemical composition. Iron at a high temperature is considered as having all the other elements present in a combined form, so that it may be considered as a solution, and like all solutions, changes take place during the cooling and solidifications. A hot iron is very different from a sluggish iron, the principal effect of cooling being the deposition of flakes of graphite, large or small, depending on the rate of cooling, a phenomenon familiar to all founders and, unfortunately, one that gives rise to much trouble. The amount of graphite that will be thrown out of solution depends largely upon the amount of silicon present, so that from that it is evident why silicon is so decidedly the ruling element. I have said that it is generally conceded that molten iron contains all the other elements in a combined form, but that this is absolutely true I should not like to guarantee, for results that appear to prove the opposite can be obtained from a suitable iron, for instance, a high carbon, high-silicon iron with low manganese, phosphorus and sulphur, if cast into very thin strips, so thin that the metal is cooled almost instantaneously, will most probably have very little above 0.3 per cent. of carbon in the combined form. (The small strip on the table has but 0.25 per cent. C.C.) It is such points as this that open up room for the research chemist, and in this research the help of the practical foundryman is sought, and if he but holds out the hand the scientist will be very ready to grasp it.

Practically all material used should be subjected to analysis and, if possible, bought to specification, and though in some cases this might raise the initial cost, yet I am sure that in the end it would be a saving. Taking cupola coke for instance, no man can tell a good coke by the appearance, though given cokes of even value in composition, the practical man will be able most likely to choose the best for his needs. The chemist can watch the cupola—he should do, both at the charging door and the tapping hole—and such material as gannister, blacking, limestone, and the moulding sand should always be tested in the laboratory. So great is the standing of the chemical laboratory among foremost foundries, that it would be useless to try to dissuade them from its benefits. In no other way can so uniform a quality of iron be produced, and when once the foundryman decides to use the information unfolded by a careful analysis, he seldom or never goes back to the old way of "hit or miss." Great saving can be effected by carefully watching the market prices of material and employing a chemist to calculate the mixtures according to these prices.

Discussion.

Mr. W. H. Sherburn remarked that science and the chemist did not always mean the same thing. Science was not merely read in a book or learned at a University; it represented organised, classified experience. If that was true, then there had always been a considerable amount of science applied in the foundry. Even in the benighted days to which Mr. Harrison had referred, things were made which could not be surpassed at the present day. Unfortunately a great amount of trouble had been caused by the way in which so-called scientific men had been introduced into foundries and the manner in which they had carried out what they conceived to be their duties. In other countries—notably Germany—science had been applied in the foundry for a long time, but it had been introduced in the right way. The aim was to make the foundrymen scientific; that was the right method, and he believed the technical schools in England were now making progress in that direction. In addition to that, a properly trained chemist would fulfil a useful function in the works, but unfortunately in the past the foundry chemist had often been a man who had never come in touch with practical work before being placed in a responsible position, and yet he had been expected to correct the mistakes and failures of men who, however, lacking in some respects, had a knowledge gained by actual work. If the right course had been pursued the chemist would have realised that he did not know everything, and that if he was in a position to teach some things, it was also necessary that he should learn a great deal. In other words, the practical and the theoretical should be combined. Mr. Harrison had suggested that the chemist should be given a position of responsibility. If he was fitted for the post, no doubt that would be desirable, but very often he was not, and could not properly control the men who were supposed to be under him. The question had been asked, "Why grade iron?" The reason was that a classification of some sort was required. With all its shortcomings number grading had been a satisfactory method of classification in the past; it was not quite so haphazard as Mr. Harrison implied. Within reasonable limits a man could judge what was meant by No. 1 iron, No. 2 iron and No. 3 iron; so far as was necessary for his purpose he could choose the iron he needed by the look or by the feel, without the assistance of the chemist.

Mr. Penlington remarked that it would appear that in the old days they had fewer defective castings than were produced in the foundries to-day. He agreed with the previous speaker's criticism of the way in which the foundry chemist was introduced into the trade. Employers experienced trouble in the running of the foundry, and it was unjustly regarded as a department which lost money; so when the idea was started of bringing in the chemist to improve matters, the employer welcomed the chemist with both hands and expected that he was going to work miracles. Now the chemist in those days was like other people who learn a little about a subject and thought they knew it all. He advised a certain mixture, and if it was not satisfactory he blamed the foreman or the men who had done the work. He shelved the responsibility which had been laid upon him and was at variance with the other men in the shop. If, without rushing from one extreme to the other, a middle course had been taken, and the chemist had been asked to blend his science with the practical knowledge of the workmen, the results would have been far different and the friction would have been much less. Until there was a better method of melting the pig-iron he did not think there would be much improvement in the castings. The results obtained by putting steel into the cupola were interesting. He had known 15 to would have been much less. Even with blast furnaces it was not always possible to foresee what would be the product. Varying results were produced by 20 per cent. to be added with fairly good results, but he had no knowledge of a case where the proportion was as high as 30 to 50 per cent. Perhaps the type of casting had something to do with it. The analytical chemist could be helpful in the foundry, not only in connection with the actual casting but also by testing the supplies of coke, sand and other materials which were required for the various processes.

Mr. Markland remarked that when a shop was producing good results the employer did not wish to upset it. The chemist was only brought in when there were difficulties to overcome or when it was

desired to cheapen the cost in some way. It was a fact that by the judicious selection and blending of cheaper brands a good class of casting could be produced. The chemist was able to advise in such matters.

Mr. Hogg said there was a good deal for the chemist to do in a foundry where the work was of a varied character and he was sometimes placed in a very difficult position. He was held responsible for matters over which he had no real control—when a foreman who had muddled things wished to shield himself or when moulders in their anxiety to get the work done showed undue haste. The use of scrap iron raised other questions. What was the chemist to do when the foundry was making castings for people from whom it took scrap in return? In one case he had to deal with what his employer termed "good machinery scrap," and he never had more trouble than while that was going through. About the same time he received one hundred tons of scrap from a place which had been burnt down, and he was told, "It may be a bit awkward as it has been burnt, but you must make the best use you can of it." As a matter of fact it was excellent—far better than the "good machinery scrap." If Mr. Harrison could give them some information how to deal with scrap it would be very useful. It was known that when using the same mixture different results were obtained by casting in a dry-sand mould compared with those obtained in a green-sand mould. He was of opinion the difference was owing to the rate of cooling. The temperature of the casting was an important point on which the chemist and a practical man would have to agree if good results were to be obtained. The variations in the thickness of castings made a lot of difference in a machine shop.

Mr. Harrison exhibited specimens of iron and pointed out that two pieces which were bought as No. 4 varied very much in fracture, one being of very open grain and the other of close grain, but the chemical composition was the same and the results obtained in casting would be the same. He agreed with Mr. W. H. Sherburn that science was not to be found in books if it constituted bare knowledge or mere hypothesis. A better definition of what he meant by the word science would be applied theory. They might arrive at the same result in two ways, by observing facts and deducing theories from them or by forming theories and by experiment and tests proving them to be facts. When a thing had been proved to be correct it became science. He appreciated the objection to the way in which chemists had been sometimes introduced. To be properly qualified a man must combine with his chemical knowledge some degree of actual experience in the shop; that might either come as a sequel to his chemical education or it might precede it, as in the case of a moulder who worked his way up in the shop. Chemical analysis was a satisfactory substitute for grading. If steel makers could buy pig-iron by analysis instead of asking for a particular grade, why could not the foundryman do so? He did not agree with Mr. Pilkington about the inability of the foundry chemist to counteract the evil effects of bad iron by adding other material. That was one purpose which he could usefully serve—teaching how to obtain good results from imperfect material. In regard to the financial aspect, a small diminution in the number of wasters would more than cover the cost of analyses.

Asked by Mr. Sherburn whether the samples of iron shown were average samples or freaks, Mr. Harrison stated that they were selected in order to prove the point he was making, and they showed it in a somewhat exaggerated form. One could often pick from the same cartload iron of an open grain and iron of a close grain. That helped to prove the contention that grading by fracture was wrong and grading by analysis correct.

Mr. Harry Sherburn said that in a shop dealing with a large number of mixings in different classes of work the chemist had a sufficiently large field to work in, but he had not the same scope where a shop was engaged in repetition work and the same charges were being put in day after day, requiring little alteration. He could, however, render good service by analysing foundry supplies and seeing that they were up to the standard required. It was not always necessary to get the best iron in order to produce the best results; an admixture of inferior brands might be equally satisfactory in practice. He (Mr. Sherburn) did not think a true comparison could be drawn between steel makers and iron founders. The former had only a slight percentage of impurities in the finished iron—in many cases under one per cent.—but the iron founder had to deal with a conglomeration of elements where those other than iron itself were a tenth of the whole mass.

Mr. Harrison said even in a repetition shop it was not easy to see how the differences which arose could be regulated without some chemical analysis. Most commercial people now sold by analysis. If asked for iron of a certain number they would sell it, but they graded it by analysis. The time when the grading was done by fracture was gone. Asked by Mr. Hampson whether the same results would be obtained by using two samples of iron different in fracture but identical in analysis, Mr. Harrison said it would make no difference whatever.

Mr. H. Sherburn remarked that where a number of brands were in use it was not likely that all would go wrong at the same moment, and an inequality in one would be counteracted by the others. If any trouble such as sinking or springing in a casting arose from time to time it was easy to remedy it without the aid of chemical knowledge, though no doubt such knowledge would be advantageous to the man in charge. Between the steel maker and the iron founder there was this difference, that the former eliminated certain things from his material before dealing with them, but the iron founder had to deal with his materials as they came to him.

The Chairman said before they could rely on getting iron of specified analyses it would be necessary to have chemists at the blast furnaces. Those furnaces might be charged with the same sort of material, but owing to differences in the conditions the resulting products would vary considerably. There was no certainty what it would be. One could not know what the pigs were without taking analyses and a certain amount of grading. Similarly, after passing the same mixture through two different foundries different results would be got.

Mr. Andrew asked whether the difference in the quality of the iron—the percentage of silicon or phosphorus—was accounted for by the variation in temperature.

Mr. Harrison replied that the modern developments of industry, especially in America, had led to the use of blast furnaces under tremendous pressure, with an extremely high temperature, and iron which was higher in silicon than it used to be was got. The tendency was to go further in that direction. He thought blast-furnace temperatures would be still higher. As to making a good casting from a poor pig, it depended upon what was meant by the word "poor." The poorest iron that he handled contained over 4 per cent. of phosphorus, but it was used with excellent results for making cannon balls. They never knew what it was to get a bad cannon ball. As a rule the bigger the casting the cheaper the material which could be used—of course within reasonable limits.

Making Large Cast-Iron Collars.

By James H. Bingham.

The following expeditious method may be employed in the repeated production of large cast-iron collars. In the present case, three sets of tackle were used instead of one, to facilitate the speedy output of a dozen such castings. The bottom plate was cast 2 in. thick, with four handles, as shown, and it

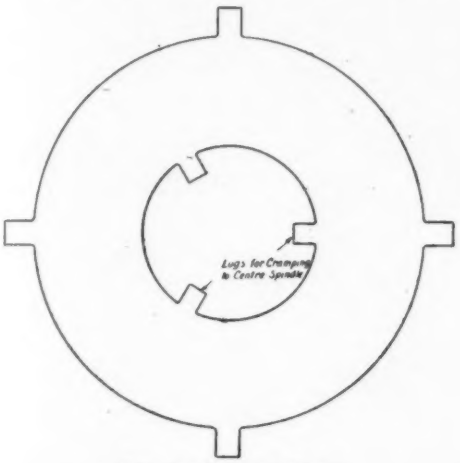


FIG. 1.—BOTTOM PLATE.

was found possible to allow a hole 2 ft. in diameter in the centre when making 30 in. collars.

The binder plate was made in two parts. The object of this will be evident; after the mould has been built up, and a collar cast, the two halves can be moved away without disturbing the arrangement

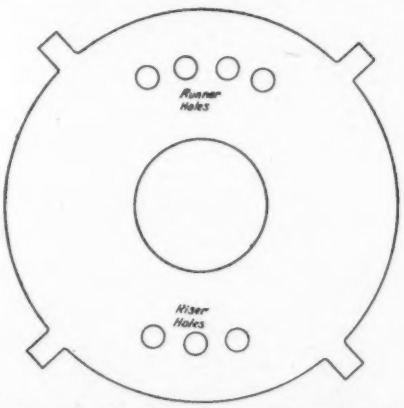


FIG. 3.—TOP PLATE SHOWING ARRANGEMENT OF RUNNER AND RISER HOLES.

of the brickwork. Once the brickwork is in position, all that is necessary is to strike up the mould with loam, dry, and put together again. Staples of $\frac{7}{8}$ in. wrought iron and of the size shown are cast into the binder plates, and two 3-in. bars wedged in these staples will serve to secure the two halves of the mould. The binder plate must not be much thicker than the width of the collar flange, otherwise an unusual thickness of loam will have to be struck up underneath the first layer of bricks. The

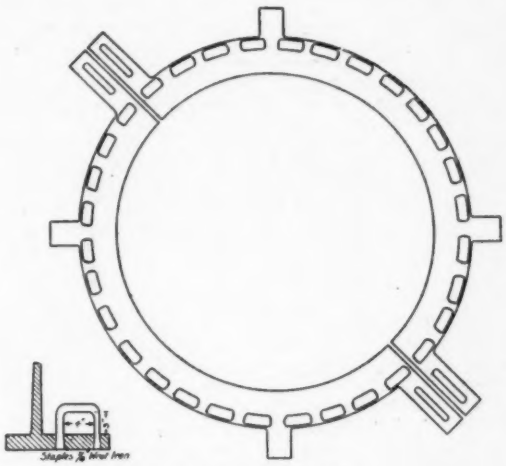


FIG. 2.—BINDER PLATE.

prods may be cast 1 ft. 8 in. long. This allows for an inch clearance to the top of the mould, the thickness of the binder plate, and 1 in. of loam between binders and bottom plate.

Thin sheet-iron plates (from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick), shaped to the collar (see Fig. 5), are inserted between the two halves of the mould, thus making parting easier when dismantling. The plates must be sufficiently wide to allow for the thickness of the brick-

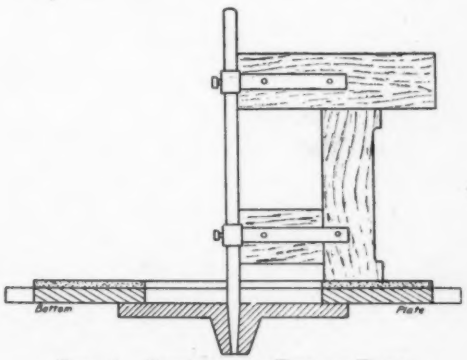


FIG. 4.—STRIKING UP BOTTOM PLATE.

work, and $\frac{1}{2}$ in. clearance must be allowed all round the plates, as shown.

The spindle centre should be cramped to the lugs on the bottom plate in the first instance, as this

will save resetting after each cast. When the bottom plate has been struck up, it is advisable to draw away the board and remove any surplus loam from the plate before drying. This saves carding after removal from the stove. After drying it should be tarred, and having been once tarred it will serve for several casts.

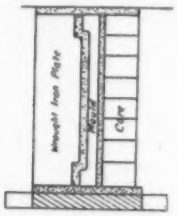


FIG. 5.—SHOWING PARTING PLATE IN POSITION.

The top plate should be made with an 18-in. hole in the centre, and handles corresponding to those on the bottom plate. Four 3-in. round holes for runners and three similar ones for risers are cast in the plate, as shown in Fig. 3. Round holes are preferable to rectangular ones, as the tendency to crack is eliminated, and therefore the plate is in no way weakened. The runner holes should be so arranged that the ladle may be held between two of the handles of the plate when pouring.

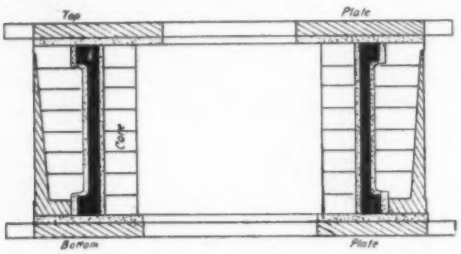


FIG. 6.—SECTION THROUGH FINISHED MOULD.

When using three sets of tackle it was found that one man and a youth were able to cast two collars and then one on alternate days.

Low-Carbon Pig-Iron in the Foundry.

In a recent issue of the "Stahl und Eisen" there appeared an interesting article by Mr. Alexander Zenzes, in which the author dealt with the use of low-carbon pig-iron for the production of high-class castings. The following abstract from the article in question is taken from "The Iron Age":—

It has long been known that the strength of cast iron depends not only on its chemical composition, but also essentially on its structure; that a good cast iron, on which the severest demands as regards strength and density can be made, must have a fine-grained structure. This can be attained with certainty only by melting iron in a crucible, because there is no essential change in the original definite mixture due to the absorption of other elements. The best crucible cast-iron is characterised by a low carbon content, which is not more than 3 per cent. In a cupola it is difficult to produce a good cast iron with less than 3 per cent. carbon, because the cupola charge of pig-iron seldom has less than 3 per cent. carbon and because also carbon is absorbed from the coke. The addition of steel scrap to produce higher tensile strength, though somewhat in favour, has also similar disadvantages arising from the use of coke, from the absorption of sulphur, etc.

A few brands of English cold-blast charcoal pig-iron have found special favour in Germany as an addition to cast iron to bring about a dense iron. They serve in many foundries, despite their high cost, as a cure-all without which dependable results are impossible. The analyses of these irons are by no means entirely good, especially as regards sulphur, manganese and phosphorus. The feature which confers on them the valuable property of producing a cast iron of very fine structure combined with density and strength is their low total carbon content.

In his capacity as managing engineer of a large Rhineland metallurgical plant, the writer was active in the iron foundry where high-class iron was made, and where large castings with a minimum tensile strength of 18 kg. per sq. mm. (about 11½ tons per sq. in.) were poured. The average thickness of all kinds of castings to be produced varied between 1-5th in. to 4 in., and therefore it was not possible to keep one cupola in operation which could produce the necessary composition for these different sections. Manifestly the strength of cast-iron sections is dependent on the structure; and the structure, in uniform foundry practice and conditions, is dependent on the chemical composition, which, however, cannot be changed so often nor in such short intervals as would be demanded by the thickness of all of the pieces to be poured. In spite of this, it was possible to pour each piece in the composition of iron suitable to its section. Daily 10 to 15 tons of castings were to be poured for which a high tensile strength was demanded. Two small cupolas of 3 to 4 tons capacity produced two grades of cast iron. One cupola, with a charge of No. 3 hematite (1 to 1.5 per cent. silicon), steel rails, scrap and Siegerlander alloy, produced a so-called hard iron of the following prescribed composition:—

	Per cent.		Per cent.
Carbon ...	... 3.00	Phosphorus	... 0.10
Silicon ...	... 1.00	Sulphur	... 0.10
Manganese	... 0.50	Copper ...	... 0.10

The other cupola, with a charge of No. 1 and No. 2 hematite, low-manganese iron, and scrap, produced a so-called soft iron of the following composition:—

	Per cent.		Per cent.
Carbon ...	... 3.50	Phosphorus	... 0.10
Silicon ...	... 2.50	Sulphur...	... 0.07
Manganese	... 0.05	Copper ...	... 0.10

To pour castings with a thickness of less than 10 mm. the straight soft iron was used; for those of 10 to 15 mm. thickness a mixture of 2/3 soft iron and 1/3 hard iron; for those of 20 to 25 mm., ½ hard iron and ½ soft iron; for iron castings of 30 to 40 mm. thickness, 2/3 hard iron and 1/3 soft iron, and for castings of greater thickness only the hard iron was used.

The hard iron of the cupola was blown with tolerable certainty of a constant quality, because the composition of the charge was constant. Nevertheless, the superintendent had a sample taken of every tap of the cupola making the hard iron, by taking a test with a spoon from the partly filled ladle after quickly stirring it. When the test piece, poured in sand and cooled in water, showed the expected amount of separation of graphite, the partly-filled ladle was then at once filled with the amount of iron from the soft-iron cupola necessary to make the mixture desired. This resulting mixture was then properly stirred with a rod of iron fastened to a piece of rail after a piece of lead had been thrown into the ladle. In this manner the volatilisation of the lead as well as the stirring gave the gases a chance to escape. Each day a test piece one meter long and 30 mm. thick was taken of the hard iron, the soft iron and the resulting mixtures, and tested for bending and other properties.

In this manner it was possible to produce every desired mixture, and therefore any casting of a de-

finite weight and limited cross-section. The most exacting demands as to density of structure and as to tensile strength and resistance to pressure could thus be satisfied. The results were decidedly satisfactory. No modifications were possible, and all chemical calculations for soft iron, hard iron and the finished product were the result fundamentally of the silicon content. A chemical laboratory was available and always open for use. Tensile strength tests of the products were taken almost daily. From the numerous tensile tests and also especially the bending and pressure tests, in conjunction with the chemical analyses, the writer became convinced that in the case of two test pieces of similar chemical composition as regards Si, Mn, P, S, and Cu, an essential difference in tensile and pressure characteristics could ensue. The literature on the subject, as well as all previous practical experience, could offer no solution of this phenomenon. It was manifest, however, from the square test pieces used to determine the resistance to pressure, that of two pieces of like chemical composition as regards Si, Mn, P, S, and Cu, but of entirely different strength, the hardness of the pieces poured in dry sand differed. From this the conclusion was drawn that the carbon content was the real measure of the physical properties of cast iron.

The analyses for total and combined carbon afforded the explanation: that of two test pieces of similar structure and chemical composition as regards Si, Mn, S, P, and Cu, the tensile strength is greater the less the percentage of total carbon and the higher the combined carbon in a test piece of grey structure. In the best cast iron with grey structure the percentage of combined carbon was from 0.80 to 1.00; of graphitic carbon about 2 per cent.; and the total carbon not over 3 per cent. Investigation of the cupola iron showed that the carbon content of the hard iron was mostly under 3 per cent., and therefore there resulted the best breaking tests with a tensile strength of 28 to 30 kg. per sq. mm. (18 to 19 tons per sq. in.) from a total carbon of not more than 3 per cent., and often less.

Attempts to produce a cast iron with less than 3 per cent. carbon from the cupola direct were unsuccessful, because no pig-iron with less than 3 per cent. carbon was available and because melting pure cast iron or steel scrap with ferro-silicon produced an iron of poor quality. Entirely different results are obtained when the white iron, blown at a high temperature in a converter, is used to mix with pig-iron. By this means a desired or calculated composition results, and a carbon content of less than 3 per cent. can always be attained. These experiments the writer announced in his patent "Process of Producing Cast Iron of High Tensile Strength." This process is used with great success in many plants having small Bessemer converters.

As regards making low-carbon pig-iron, in 1904 Henning, of Mannheim, announced a process for making a pig-iron that will produce dense castings; it consists of mixing liquid pig-iron and liquid steel. In using this process (German patent, 179,739) a converter outfit is unnecessary. Two German blast furnaces are operating very successfully in accordance with this process of Henning's, which enables blast furnaces to make a pig-iron low in carbon.

Of considerable importance is the use of special pig-iron to produce castings which shall possess special magnetic properties. A cast iron has the best magnetic properties which has a low-carbon content and a fine-grained and dense structure. The experiments of Mr. Zenzes which led up to his patent, referred to before, showed that his product had excellent magnetic properties.

Correspondence.

The Foundry and the Drawing Office.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—The only and sole reason why perspective drawings are suggested for foundry use, instead of mechanical ones, is that moulders generally cannot read the latter; nor is it often necessary they should, except in the case of loam moulders, and with them it is essential that they should be as able to understand a drawing (mechanical) as the pattern-maker who prepares the pattern tackle.

I write and speak, not from theory, but from hard experience. To work with a loam moulder who can read a drawing even only fairly well, makes the job go through much quicker and certainly much smoother between the two shops. To a pattern-maker who has the pleasure (for it is one) of working with a loam moulder who can read a drawing equally as well as himself, is, in shop language, a "boobie's job." The particular advantage accruing to the foundrymen who are able to understand drawings is the ease and certainty with which they can prepare the necessary mould tackle for the job, and the extra advantage of grasping at once all that is implied and prepared in the pattern tackle. The perspective method cannot give this help. It is not worth the draughtsman's time preparing it, and if at any time a moulder does want some assistance by which perspective may help him, a pattern-maker with a bit of chalk can usually give him a picture of what he wants.

To the average moulder, I find, a mechanical drawing is a "picture of mystery," though if he did but know that at the first glance it is also the same to a pattern-maker, he perhaps wouldn't treat a drawing so much as a thing of awe and be frightened at it. I have often heard of pattern-makers and even draughtsmen so quick and clever at reading drawings that it was only necessary, as it were, for them to see the back of them to know all about the job. But on enquiring where they could be met with, it is found that they are all dead. Once convince a moulder there is nothing difficult about reading a good drawing, and given a little help and practice, he is not very long before he "has it."

If perspective drawing is good for the moulder, it should also be good for the pattern-maker, but no one thinks of suggesting such a thing. It would be absurd. Send the drawing into the foundry along with the pattern, and give the foundry a chance to learn to read drawings; the drawings will be of more use there than laid away in the foreman pattern-maker's drawer, awaiting the "call" of the machine shop.

Yours, etc.,

V. DEWHURST.

Sheffield, April 3, 1914.

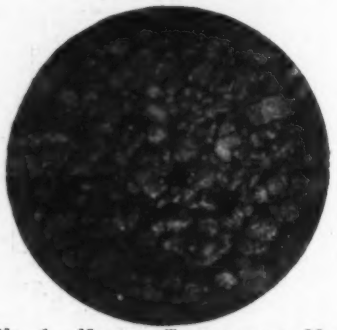
Simon Ferro-Manganese Process.

The Simon process of making ferro-manganese in the electric furnace consists in dissolving manganese oxide in a flux of fluor spar, and reducing it to metal in presence of carbon; and as the temperature can be properly controlled, and the loss of manganese is therefore slight, the process is advantageous where cheap current is available, especially as the product is lower in phosphorus and silicon than that produced in the blast furnace.

Foundry Sands and their Treatment: Tests for Refractory Values.

By Algernon Lewin Curtis, M.E.

Material Tested :—**CHESHIRE SAND (Roe Park).** *Weight of Sample* :—100 Grammes. *Colour and Description* :—Dark Brick Red. *Consistency* :—Very Weak and Open. *Surface Factor or Size* :—(Grammes per cent.)—Retained on 50 sieve, 1.100; Retained on 100 sieve, 72.370; Sieved through a 100 sieve, 26.530. *Water Required for Maximum Cohesiveness when Dried One Hour at 100 Deg. Cent.* —4 C.C. per cent. *Venting Capacity of 1 Cu. In. when Mixed 400 Times with 4 per cent. Water and Rammed at a Pressure of 25lbs. per square inch* :—About 2 lbs. Air Pressure. *Plate* :—Wellington & Ward "Anti-Screen." *Objective* :—1 in. Watson.



No. 1.—Normal Temperature. Mag. × 50 Diams.

Remarks.—This Material Works very Gritty and Weak in Moulds. Contains Large Amount of Impurities.

No. 2.—Exposure to 1,200° C. Mag. × 50 Diams.

Remarks.—Test Piece showed very Slight Expansion, and Broke During Cooling. Much Weakened by Heat, Expoliation and Fritting.

No. 3.—Exposure to 1,300° C. Mag. × 50 Diams.

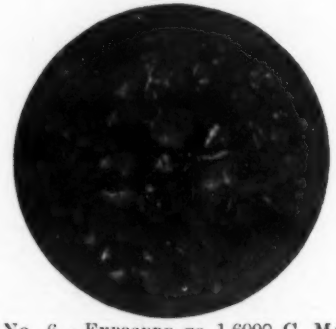
Remarks.—Test Piece Expanded $\frac{1}{64}$ in. in the Form of a Camber in Length of 2½ in., then Broke on Cooling. Greater Weakness, More Exfoliation and Fritting.

No. 4.—Exposure to 1,400° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Much Weaker with More Exfoliation and Fritting. Fusion began by partly Cementing Specimen's Surface.

No. 5.—Exposure to 1,500° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Material Fused in Bunches or Aggregates. Much Weaker and More Exfoliation.

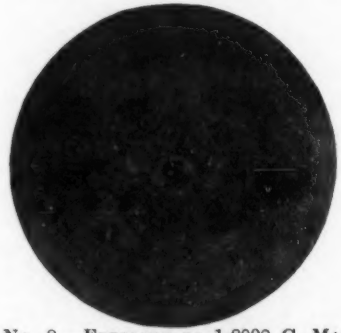


No. 6.—Exposure to 1,600° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Material Nearly Completely Fused. Weaker with More Exfoliation. Heavily Pitted and Fissured by Iron, etc.

No. 7.—Exposure to 1,700° C. Mag. × 50 Diams.

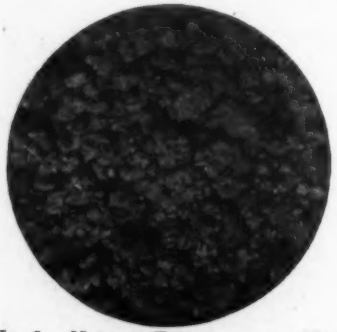
Remarks.—Test Piece Broken by Heat. Great Exfoliation, Material Completely Fused to a Whitish-Grey Glass. Heavily Pitted and Fissured.



No. 8.—Exposure to 1,800° C. Mag. × 50 Diams.

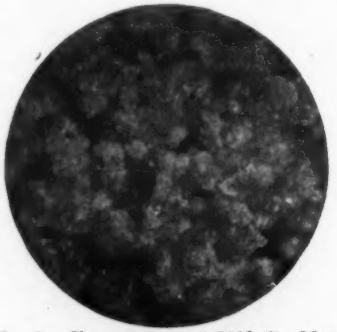
Remarks.—Test Piece Broken by Heat. Greater Exfoliation. The Whole Face of Test Piece Completely Fused to a Whitish-Grey Glass. Heavily Pitted and Fissured.

Material Tested :—**CHESHIRE SAND (Runcorn).** *Weight of Sample :*—100 Grammes. *Colour and Description :*—Light Brick Red. *Consistency :*—Medium Strong. *Surface Factor or Size :*—(Grammes per cent.)—Retained on 50 sieve, 10.610 ; Retained on 100 sieve, 58.300 ; Sieved through a 100 sieve, 31.090. *Water Required for Maximum Cohesiveness when Dried One Hour at 100 Deg Cent. :*—3.50 C.C. per cent. *Venting Capacity of 1 Cu. In. when Mixed 400 Times with 3.50 per cent. Water and Rammed at a Pressure of 25 lbs. per Square Inch :*—About 4 lbs. Air Pressure. *Plate :*—Wellington & Ward "Anti-Screen." *Objective :*—1 in. Watson.



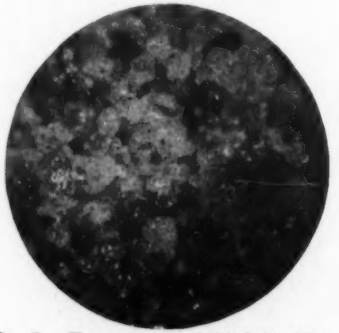
No. 1.—Normal Temperature. Mag. × 50 Diams.

Remarks. — Medium-sized Sand. Works Well and Clean in Moulds. Requires little Water.



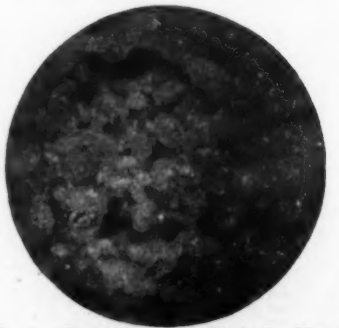
No. 2.—Exposure to 1,200° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{16}$ in. in the Form of a Camber in a Length of $2\frac{1}{2}$ in. Specimen Strong and Unbroken by Heat. Bleaching out of Clay Substance Begun.



No. 3.—Exposure to 1,300° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded as in Fig. 2. Specimen Strong and Unbroken by Heat. Sand Grains Began to Fuse Together.



No. 4.—Exposure to 1,400° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded as in Fig. 2. Specimen Strong and Unbroken by Heat. Sand Grains Fused Together in Bunches or Aggregates, showing some Pitting and Fissuring.

No. 5.—Exposure to 1,500° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded as in Fig. 2. Specimen Strong and Unbroken by Heat. Material nearly Fused, showing Pitting and Fissuring.

No. 6.—Exposure to 1,600° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. No Exfoliation. Material not quite completely Fused, showing considerable Fissuring.

No. 7.—Exposure to 1,700° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{16}$ in. in the Form of a Camber in a Length of $2\frac{1}{2}$ in. Specimen Strong, showing no Exfoliation and Fusing to a Clear White Glass, Heavily Pitted.

No. 8.—Exposure to 1,800° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded as in Fig. 7. Specimen Strong, showing no Exfoliation and Whole Face of Test-piece Fusing to a Clear White Glass.

A Day in the Foundry.

Before the Birmingham Branch of the British Foundrymen's Association, on March 28, Mr. J. G. Robinson, of Halifax, delivered an illustrated lecture entitled "A Day in the Foundry." Mr. C. Heggie (President of the Branch) was in the chair.

In choosing the title of the lecture, said Mr. Robinson, he had been influenced by the fact that on several occasions when going round the foundry and looking at the different jobs, certain differences of opinion had cropped up, and he thought that if these little conversations and the observations made on different subjects had been recorded they would have formed a very interesting Paper for discussion. He would, therefore, consider that they were looking round his own foundry, and take them round and show them how the work was laid out and the methods that were adopted for the different jobs.

Commencing Work.

The work in the foundry began at six o'clock in the morning and was continued until five in the evening, but the moulders at six o'clock in the morning were required to start moulding, not mixing sand and getting boxes. Therefore the labourers came in at five o'clock in the morning. In addition to that there was always a night man, whose duties were to take all the bolts out of the boxes which had been cast over-night and laid down, previous to the moulders knocking off work. The night man who did this was expected to keep all the nuts and bolts in one place; he also got the boxes and the small castings up and attended to portable stoves used for drying moulds made in the floor and the ordinary core-drying stoves. The latter were gas-fired; they were fired during the afternoon, and were filled up at five o'clock, so that they required very little attention during the night to ensure a constant heat being kept up. A pyrometer was used in each of the stoves, and the nightman's duty was to see that the heat was kept up to about 500 deg. F.

A card system was in use by which every job was checked and the costs were taken out each week. The first job to which he would direct attention was a piston. The piston moulds were under a swing frame on the side of the job, because though they were fairly small, they were really crane work. The crane had been specially fixed for them, and saved a good deal of waiting on the travelling crane which was used at that side. In a view of the dry-sand shop, which was shown, would be seen the mould for a horizontal gas-engine cylinder. Farther along was the pit which was described at length in the speaker's previous Paper on moulding a crank-case casting (see Foundry Trade Journal August, 1913). Facing that, on the other side of the shop, was the pig-bed, which was always kept ready for dealing with the first or spare iron. The cupolas, of which there were two, were beside that pig-bed; both had receivers and drop bottoms.

The Iron.

Different grades of iron, a certain proportion of soft iron, and a special iron for cylinder work were employed. They could not always run the cupolas altogether on cylinder work, and they had also to arrange for jobs that had to be cast with very hot iron, and for which it was necessary that the cupola should be thoroughly warmed. They therefore arranged to deal first with some job on which there was very little machining required, say a horizontal gas-engine bed, or a flywheel which would take about 3 tons of iron. When that had been disposed of, everything had got warmed up—the cupola, the receiver, and the ladle, and they could follow on with the special iron. By fixing a definite quantity with which to charge the cupola and using a three-ton ladle it was possible to take out from the cupola practically that three tons, or if they wanted to take shanks off they could allow for that in the charging. In that way they were sure of getting iron for the best work in the place where it was wanted. Of course, the safest way was to blow down absolutely, charge up a fresh bed of coke, and then put on the special iron; but when it was known that a definite quantity had been charged in the cupola, there was a fair certainty of getting what was wanted for the best work. If it happened that the iron did not come down hot enough, then the pig-bed alongside was utilised. The first ton would indicate whether they were getting the stiff iron that everybody must have at some time or other, and by running it into the pig-beds they got the resulting scrap in pieces of convenient size, instead of having to dig grips all over the shop. Then near the pig-beds was a bed for open-sand work, such as core-plates and core gratings. There were two lengths of 6-in. by 3-in. T-iron, about 14 ft. long, and about 8 ft. apart, fixed permanently, so that every day when a level bed was wanted the sand between these two irons was dug up and strickled off, giving a level bed. This arrangement also had the advantage that it kept all that work together for the core-makers, so that they did not have to walk about the shop to find a clear space. With the arrangement described the resulting scrap was readily dealt with, and the core benches being at that end of the shop all the core-making work was kept together, and the work could be carried into the stoves, which were close at hand, for drying.

Handling of Cored Work.

As the work came out of the stoves each morning it was cored up and closed. Certain men were kept regularly on that work, and this prevented a lot of errors in coring. Each man, in fact, kept constantly to his own work, and the assistant in finishing the mould was usually an apprentice between nineteen and twenty years of age. An apprentice who was nearing the end of his time, by being put to work with a man who was closing up and finishing the job right up to the moment for casting, gained a certain amount of confidence that he could not gain in any other way, so that when he came to work by himself he would be much more confident in closing his work than otherwise he would be.

The core stoves were gas-fired, erected by Hislops, of Paisley. On the outside of the stove there was a gas-producer plant. The gas coke was charged into the producer. The maker's design had been altered somewhat by a coil of steam pipes over the top of the gas inlets. Water was admitted into the pipes and was turned into steam, which was conducted underneath the fire, forming really a forced draught which passed through the coke into a flue, which ran along the end of the stove. A temperature of 1,000 deg. F. could be got in that stove. One stove was 36 ft. by 18 ft., and three were 36 ft. by 11 ft., the height being 10 ft. They were all supplied from two gas producers. The advantage of these stoves was that they were fairly clean; they

did not have so much smut in them as some others had. A fairly constant heat was kept up in the stoves during the night. By 7 o'clock in the evening the temperature was raised to about 500 deg. and that would continue until about 5 o'clock in the morning, when the coke was getting "burned down."

Next was shown a view of the core-makers' part of the shop and the stove-doors, which were simply wrought-iron frames filled with asbestos. Although the doors were fairly large, 20 ft. by 12 ft., they were so arranged that one man could move them up and down.

The opposite side of the shop, that where the green-sand work was made, was next illustrated. One of the moulds shown was for a flywheel 7 ft. 6 in. in diameter and weighing about 3 tons 15 cwts. That was the largest wheel they made from a pattern; cast-iron patterns up to that size were kept. Near that would be seen a set of boxes reared up against the wall and hinged. It was very useful to have a set of boxes like that. Different jobs in green sand were shown ranged along the floor, and at the end was a flywheel mould struck out in the floor. The smaller plate work and the smaller loose patterns were made in a separate shop.

A Core Mixture.

In another part of the shop the cylinder liners were made. They were plate-work. Some of these castings weighed up to 12 cwts., and by making them on plates an enormous amount of expense was saved. On one side of the shop two cranes ran close to the gangway on which the metal was brought and on which the moulds could be taken to the stoves to be dried. Another part of this shop was where the pipes were made, this work being kept to one end. At the side of those moulds was a Jones and Attwood core-making machine, which for a straight length of pipe was a very useful machine. At first they were not very successful with these cores, but the sole cause of the trouble was using too much new sand. The mixture now used was one part new sand to 5 parts old sand, and a riddle half full of sawdust to a barrow of sand, and very good results were obtained. They could begin the work at 2 o'clock in the afternoon, and if the stoves were fairly hot they cast anything up to 9-in. pipes the same afternoon. At the other side of the shop the core-makers were placed, and close by was the gangway leading to the core stoves in the other bay, so that the cores for the pipes had not to be carried very far.

Gas-Engine Pistons.

The gas-engine pistons, moulded in the first shop, were machined all over, and that decided the manner in which the casting was run. A cylindrical casting which had to be machined must be cast on its end. Then came the question as to which end should be cast uphill. That had to be decided by the casting itself, because no one would dream of leaving anything to come off at the solid end. As to the best method of moulding these pistons so as, if possible, to do away with chaplets, a view was shown illustrating how the body core was carried. The core had a bearing at the open end of the casting. In some similar jobs he had seen the pattern moulded on its side. These were moulded on end. The print for the body core was made 1½ in. to 2 in. larger in diameter than the outside of the casting. The core was made to match the print so that when fixed it took a bearing on this 1½-in. and was really suspended. In ramming up the mould the boxes used were 9 in. and 12 in. deep and were used in numbers to suit the depth of the casting required. The whole lot was then turned over, the pattern was drawn out, and the mould was finished and taken into the stove and dried. The cores were made by means of a half box.

The cast-iron grids and finished cores were next dealt with. The cores were made in oil-sand, which required no ramming, so that an enormous amount of trouble was saved. At the time the core was made, four holes were put in through the top print. These were used for runners and risers. The mould, after it had been dried, was taken out of the stove and the whole brought together. The core was fixed in its place to the seating, the print ensuring that. A very little under one edge of the core would throw it out of true, and would cause a variation in thickness at the bottom end of the piston. That was why they had the bottom joint of the boxes in the position shown. After the core had been fixed in its print, the box with the mould was lifted away from the bottom part, so that the moulder could look underneath it and see that he had an even space allowed for thicknesses of metal and, at the same time, clear out any dirt that might have dropped into the bottom of the mould. After the moulder had assured himself that everything was correct, the whole was replaced and bolted together. According to the size of the piston, they either rammed up a green-sand top box or fastened the core down by bars across the box. Runner pegs were put into some of the holes left in the core and the runner bushes were made up. The reason why they put in the four holes was to have a runner wherever it might be found to be convenient, according to where the bars in the top box part happened to be. Usually two were used for runners and one for a riser. Personally, he believed in running everything as far as possible from the top, because if the metal was run straight down there was no chance of any scum forming, and there was a certain amount left for cutting off.

Water-Jacketed Gas-Engine Cylinder.

In the next view was shown a water-jacketed gas-engine cylinder for a vertical engine. In making this cylinder a great deal of trouble had occasionally been experienced; and although at the present time they were getting very good results, success was not obtained at the first attempt. But during the last two years only two cylinders had been returned from the machine shop. These cylinders were cast vertically with the end at which the explosions takes place at the bottom. This end required to be perfectly sound, while also the other end lent itself more easily to an allowance for a rising head. At two places along the bore large variations in the thickness of metal were shown. These had caused considerable trouble by developing sponginess during machining. This had been overcome by the use of "chills" (denseners).* Originally the denseners used were all of uniform thickness, but this was not exactly a success, owing to the fact that although the thick place nearest the bottom was quite sound, there was a place immediately below the upper one which was spongy. These upper denseners were then changed from 1¼ in. thick to ⅝ in. thick, and good results were obtained.

The method of applying the denseners was shown on the centre of the barrel core. These consisted of six segments of cast iron, each ⅜ in. shorter than ¼th of the diameter, so that when they were fixed there was a space between each to allow for the contraction of the casting and the expansion of the densener. This space was filled with loam. The outside diameter over the denseners was made ¼ in. less than the remainder of the core, and when the

* NOTE.—The term densener, which we have in the past suggested in place of "chills" when these are used only for closing the grain and not for giving a chilled or white iron, appears to have met with approval in foundry circles, and will henceforth be adopted in our columns.

casting was cool this left the hole practically uniform in diameter.

Cylinder Liners.

The method of making the cylinder liners was next described. All these castings used to be made from loose patterns, but they were now made from plates, from the smallest liner to those of 12 cwts. or 14 cwts. Boxes were made which would suit one liner, and would take three or four sizes below. On the half-pattern shown was what looked like a core-print, but was really the part of the pattern which formed the runner-bush. Instead of having the mould made first and then fixing the runner-bush on the top after everything had been finished, that runner-bush was moulded as part of the pattern. On the outside half of the pattern there was a riser taken up. By fixing the pattern on a plate there was no joint to be made. The larger moulds were made under a crane. The top part of the box was put on the plate and rammed up; then the whole turned over and the bottom part of the box rammed up. The plate was clamped to the bottom half of the box, and box and plate with pattern attached were lifted away from the other half of the box. By this means the box pins were used as a guide for drawing the pattern in both top and bottom halt of box. The bars in the boxes were shaped to suit the pattern, and inside the bottom edge of the box there was a narrow flange which enabled gaggers to be done away with. There were unequal thicknesses of metal round the bore, as described on the vertical cylinder, and the same methods of densening from the centre core were adopted to obtain sound castings. After the mould was finished and dried the centre core had a bearing in the prints at each end. When this was fixed in its place, the boxes bolted together and reared on end, the job was ready for casting, as both runners and risers were formed by the pattern. By this means a great saving in time was effected.

With the hinged boxes every bit of space in the box was utilised. The box was 4 ft. 6 in. square, and the bottom parts 10 in. deep, without bars on the bottom. A job could be made in that box any depth that was required. On the bottom part of the box on the outside there was a flange 10 in. wide, which made the box part and parcel of the foundry floor, so that one could work a job of any description in one of these boxes without weighting down. When the box had been lowered down by a crane, it only required the two bolts for fastening together. These were useful boxes.

Horizontal Engine Bed.

Next was shown the method of moulding a horizontal engine bed. This was made from a pattern of skeleton design which left practically all its own cores instead of the method in more general use, which was to use a block pattern and separate core boxes. By this method more uniform thickness in the casting was obtained. This was made in dry sand in the foundry floor and was dried by means of portable stoves, binders being used instead of weights for holding down the top part of the moulding box.

A Flywheel Struck Up.

For a flywheel the mould was strickled up in sand instead of a pattern being used. Personally, he was rather surprised at the amount of strickling work that was done in loam as compared with sand. When consideration was given to the quantity of tackle required for making loam work before a start could be made, and the amount of cleaning up afterwards, he could not understand why so much loam work should be done. In this case they struck up the mould in the floor in sand. The wheel under consideration was 8 ft. in diameter, 24 in. wide, cast in halves with barring teeth, and weighed about 13 tons.

These wheels used to be cast one-half at a time, but were now cast both halves at once by using a double centre and two spindles. Splitting cores were used to form the joint. The spindles were fixed originally at 3-in. centres but it was found that the cores on the joint were too delicate, so the centres were extended to 7 in.. This gave sufficient thickness to use a good strong core grid, by which the cores were strengthened and could be handled safely. In commencing the moulding operations a hole was dug in the foundry floor about 6-in. larger all round than the diameter of the wheel required. The spindles were fixed in the centres and a strickle board attached. This gave the outside diameter of the wheel and at this point facing sand was placed forming a ring about 4 in. by 4 in. The remainder of the hole was then filled with floor sand and the whole well rammed. This operation was repeated up to the joint line, when a strickle board was used to strike off a dummy joint on which the top part was rammed. On this, runner and riser pegs were fixed, also short tubes for connecting the hot blast for drying. The top box part was fixed, rammed up, and guide stakes driven into the floor to ensure the top being replaced in the same position when the mould was finished. After the top was lifted off, the hole was again dug out about an inch smaller than the diameter required. The strickle board for the mould was then attached to the spindle and the mould strickled out. By ramming up the ring of facing sand in the first place all that was required for finishing after the strickle, was to rub with a cork rubber and wet-black. The top part received similar attention, after which it was placed over the mould and the whole dried by means of portable stoves.

In preparing the cores it depended on the nature of the job what procedure was adopted. Sometimes the arm cores would turn over and make right- and left-hand. These were carried by core grids as in most foundries. A little variation they had adopted was that instead of having the lifting staples in the grids with a circular top, they had a certain amount of straight, by which means the cores were more easily adjusted when placing them in the mould. In addition to the arm cores there were the splitting cores for the boss and also for the rim, to which were attached the cores for dowel pins and the cores to form the teeth for barring gear.

In coring the mould the first cores fixed were the arm cores on the joint, then the splitting cores in the rim and afterwards the teeth cores, which were set to a distance piece worked from the spindle. The spindles were then removed, the splitting core for the boss and the remaining arm cores fixed. All places where it was necessary for the top part to take a bearing, as also the vents from the cores, were dusted with whiting and the top tried on. After removing, holes were cut through the top to connect the vents, and after being assured no crushing had occurred and the top had a bearing where necessary, it was replaced and weighted. The metal was run in at the boss, and risers taken from each arm end and the casting was fed at each of these places.

Discussion.

Mr. J. Shaw said he was not quite sure that people did not do so well in loam in moulding flywheels as with sand without very much more expensive tackle. He could not speak from experience, but he had seen these jobs made in loam with more certainty than was possible with dry sand. Of

course, a good deal depended upon the methods customary in the shop. If the manager or foreman was a loam man he would do a great many things in loam which in other works would be done in sand. Personally, he thought the job could be done quite as quickly, and certainly as safely, in loam.

Mr. E. H. Broughall (Coventry) did not agree with Mr. Robinson in running three tons of metal down every day before casting. He did not think that the lecturer could always find three tons of castings in which to utilise this metal, so that some of it, at least, could not be used to advantage, and the cost of melting it, therefore, was a loss. In regard to machine moulding, he was quite sure that the lecturer did not fully appreciate the advantage of modern machine moulding or he would not be using an out-of-date appliance. A moulding machine should make a mould complete, *i.e.*, ram up the box, vibrate the pattern and withdraw the pattern from the mould. The machine mentioned by the lecturer simply gave a mechanical lift. Mr. Robinson had impressed upon them very strongly that making moulds from patterns mounted on plates saved a great deal of money; that idea used to be entertained in a large number of foundries, but he (Mr. Broughall) could not see that to have mounted on a plate a pattern such as the liners mentioned was any cheaper than using a split pattern, except that he believed it did enable them to employ a certain amount of unskilled labour to do work by methods which a skilled moulder would not do. He was very pleased to see the good use which Mr. Robinson made of denseners. The trouble Mr. Robinson had experienced through using these on the liners was not due to the denseners but was owing to the wrong arrangement of them; moreover, as generally used they did not altogether make a casting cool equally; what they did do was to accelerate the cooling of the thick portions of the casting. In explaining the trouble with these liners, Mr. Robinson stated that the lower parts of the liners were always sound and the top parts inclined to sponginess, and this was no doubt due to some extent to the extra pressure on the metal in the lower part of the mould compared with the top part of the mould. The speaker was rather surprised that Mr. Robinson did not use high runners in order to get pressure on the liner castings. In all the illustrations shown, these liners appeared to be made with the usual runner head. The speaker's practice was, with certain castings that must be sound, to use down runners as high as 4 ft. or 5 ft.; this type of runner considerably increased the pressure of the metal, resulting in sound castings.

Continuing, the speaker said he was much disappointed to notice the boxes shown had square corners instead of rounded ones, which were much stronger. The lugs also should be narrow and deep, whereas those shown on the screen were just the reverse, being wide and thin and naturally extremely weak. It was just as important for the foundryman to have well-made and well-designed tackle as it was for the man in the machine shop, but, unfortunately, the foundryman was too often left to his own resources, and he had to design and make his own tackle under great disadvantages. The bad tackle used in some English foundries to-day was no doubt accountable for a great deal of the troubles and disappointments in the foundry. Mr. Robinson had not dealt with the daily testing in the foundry, though it would be admitted that no foundry could be run properly unless there was a systematic daily test of every mixture used. Nor had he mentioned sand mixing. Upon this point he (Mr. Broughall) was very keen, because he honestly believed that a great number of defective castings were made through the sand not being properly mixed.

Mr. Robinson, replying to the discussion, said that no doubt Mr. Shaw was right in saying that there was a great deal in the practice of any particular foundry that was due to heredity. He did not deny for a moment that quite as good work could be done in loam as in sand. Loam moulding was absolutely the safest, but the drawback to loam moulding was the amount of tackle required. When the work could be done practically as well in sand it might just as well be struck up in sand. In loam moulding bricks were usually used, and all these had to be cleared away and cleaned, and there were the plates and other tackle adding to the expenses and the labour. He considered that there was an enormous amount of money spent on loam work which could be saved by striking up in sand. As to first taking three tons of iron through the cupola every day, it was very seldom that they had not a day when they could use the three tons for flywheels and engine-beds, which did not require, as a general rule, the same amount of machining as did other engine work. For such a flywheel, one weighing, say, 30 cwts. or over, it was not necessary to run with hot iron; to do so would sometimes cause sand-burnt castings and spoil the appearance. Some of the beds they made were machined on the faces where the cylinder sat, and these parts were cast at the bottom, so that they were sure of a good machined face. In addition to this work they were always having a certain amount of work such as balance weights, so that there were very few days on which they could not use the first three tons of iron. With regard to the moulding machine, he had only spoken with regard to the jobs they had in their foundry, and the things they had suitable for a machine were not made in large numbers. If they had a moulding machine which would deal with large quantities they had to keep pace with it to get the advantage of it. With regard to the chills or denseners being wrong, all that was necessary was a variation in the thickness of the densener. Originally, they did not use a densener at all on the bottom, they only used a thick one underneath the flange, and they found that this solidified the metal and prevented it feeding the part immediately below. By putting a thinner densener which struck back a shorter distance, the metal was allowed to feed that part immediately below. With respect to the depth of head and pressure in the casting, he did not think there was anything in it. He was not speaking without experience, because at one time he had a large number of cylinders to make for a certain railway, and from his experience with those he came to the conclusion that there was nothing to be got by casting from a high head. If they got the right material and the correct heat, then a 6-in. head was as good as a 40-in. As to testing, they took daily tests, including the "K" test, transverse test, and tensile test, of every mixture that they used. They were able to get in some of their mixtures over eighteen tons tensile strength. With regard to the oil-sand mixture, they use a local production, and found that to be as good an oil for sand mixing as they could desire. The mixture was one of oil to 40 of sand. They had gone as far as 60 to 1, but he thought that a 40 to 1 mixture was sufficiently strong to do all the work for which they required oil-sand. In conclusion, he remarked that Mr. Campbell (the director of the Company) had allowed the works photographer to take the photographs and prepare the slides at no expense to him (Mr. Robinson), and he wished to take that opportunity of thanking Mr. Campbell for his kindness. (Applause.)

Effect of Gases in Steel Castings.

Dr. J. O. Arnold (Professor of Metallurgy at the Sheffield University, Applied Science Department), before the members of the Sheffield Branch of the British Foundrymen's Association, on April 3, delivered a lecture dealing with the internal structure of steel and the elimination of dissolved gas from steel. Mr. Thos. H. Firth (Branch-President) was in the chair, and there was a large attendance.

Professor Arnold said he wanted to put before those present a view regarding steel metallurgy which, he fancied, was not generally recognised, namely, that there were two great branches; one was the science of steel metallurgy, and the other was the art. These two were co-ordinate and co-equal; the one was no good without the other. So far as steel castings were concerned, the science consisted in the steel-maker giving metal of the proper composition, in the proper "killed" condition to the steel founder, with whom rested the art. The lecturer showed on the screen a photograph of two split ingots of exactly the same composition, and each melted in the same furnace. The one, he pointed out, which contained about 0.01 per cent. of aluminium, was chemically "killed" by this aluminium, while the other one, which had no aluminium added to it, was not "killed" at all, but was consequently completely full of blowholes, and as a casting was worthless. Blowholes were caused by gas which came out of the steel when solidifying. The gas in blowholes was not, as many ironfounders supposed, trapped air; it consisted of hydrogen, carbonic oxide, and, in a small quantity, nitrogen.

The earliest form of steel casting from the celestial regions was the meteorite, which almost invariably consisted of a very mild steel containing about 6 per cent. of nickel. Curiously enough, a meteorite coming millions of miles to the earth had exactly the same structure as that which was produced in the crucible or the Siemens' furnaces to-day. Steel was a crystallised igneous rock, just like granite or any other rock, and in this crystallisation there were two factors—a molecular crystallisation invisible to the microscope, and an external crystallisation visible to the microscope, or to the eye. A steel casting to be any good must be "killed"; it must be freed, he would not say from gas, but from surplus gas. This question of gas in steel had to be considered more seriously than had hitherto been the case, because it was the one branch of metallurgy that science had not yet been able to penetrate. It was possible to get a volume of gas out of what was apparently sound-looking steel, which would be several times as great as the volume of the steel itself.

As to what was the effect of this gas in different sorts and conditions of steel, as affecting its properties, this was not known; but it had a very great effect and a varying effect, and this was where the further patient investigations of science would have to be relied upon, to get not only steel free from surplus gas and blowholes, but also free from the still dissolved gas which could not be seen but which might affect the steel injuriously in very many ways.

In Sheffield at the present time, said Professor Arnold, experiments were being carried out on a huge scale to remove dissolved gas from steel, and he thought they presented a considerable prospect of success. When this was done there would be produced a new steel which had not been known before to steel metallurgy—a steel which had not been de-gasified, but very largely de-gasified; and he predicted that that steel with the same composition in many respects would have very different properties from steel containing dissolved gas.

Dealing with annealing, the speaker said that this was essentially an operation of re-crystallisation, or, to be more accurate, of destroying the acute crystallisation of the original casting. There was another very important action in annealing, which was discovered many years ago in what was now the Sheffield University, and which had to do with certain cracks to which small castings and small parts of large castings were often liable. For want of a better term he had called these cracks "sulpho-membranes." Annealing destroyed the acute crystallisation of the steel, and balled up these sulpho-membranes. Sometimes, however, there were sulpho-membranes which would not ball up or form into minute globules, and nothing was so detrimental in steel castings as the production of these sulpho-membranes which would not ball up. Test steel castings could not be made out of iron and carbon. Some other element or elements had to be added, and those were silicon and manganese. From his experience the average test casting he advocated was carbon 0.35 per cent., silicon 0.25 per cent., and manganese about 1.0 per cent. Manganese would raise the resistance to stress and the steel would still retain its ductility.

Discussion.

Dr. Longmuir, in opening the discussion, remarked there were in the steel trade very many branches, but none of them, as far as he knew, demanded so much personal skill as that in which the moulder was engaged.

Dr. Hatfield said that the action of silicon, manganese and aluminium in preventing blowholes was a very involved question, and although they had been using these elements in the making of steel for over 30 years, they were really in a fog as to the exact means by which they caused the dissolution of the gases.

Dr. Swinden said that in regard to the explanation of the "killing" of steel it was rather amusing to read the various explanations put forward. Two main schools appeared to exist—the one which claimed that the best method of obtaining sound ingots and sound castings was to keep the metal fluid as long as possible so that the gases would come out; and the other school which added elements that were claimed to increase the solubility of the steel for gases and to keep them in. These two points served to illustrate the very mixed-up state in which the theories on this matter really were. So far as investigating the subject was concerned, he thought they were a little bit nearer than was the case in the very early days. As to how these gases existed in steel, they had very little knowledge indeed. It was, he supposed, generally assumed that oxygen existed in the form of dissolved oxides. It was known that tough copper held in solution a certain definite proportion of copper oxide, but in regard to steel the subject was involved, because the oxygen might exist as ferrous oxide, or as manganous oxide, and one of the points which would need very careful consideration was how to separate these two oxides in estimations.

On the motion of Mr. Crowther, a hearty vote of thanks was passed to Professor Arnold for his lecture.

Improvements in Thermo-Electric Pyrometers.

That the thermo-electric pyrometer is the one most widely used for industrial purposes is probably due to the primary facts that (1) it is simple in construction, (2) sufficiently accurate for practical purposes, and (3) comparatively inexpensive in first cost and maintenance. During the last few years remarkable progress has been made in the direction of simplifying, cheapening and adapting thermo-electric pyrometers to the requirements of everyday practice. This is the age of "base-metal" thermo-couples, an element usually consisting of one constituent of nickel, or a nickel alloy, and the other of a similar alloy in different proportions, or of iron. Whilst these couples have the advantage of cheapness in first cost and great strength, they cannot be used for temperatures above 1,000 deg. C., and also lack permanency of their electrical qualities. It is claimed for the Leskole base-metal thermo-couples (of which specimens are shown in Fig. 1) that they are free from these defects. This element has for its constituents nickel and carbon. The construction is as follows: A stout wire of pure nickel passes down inside a special carbon tube. The two are joined by welding the nickel wire into an iron plug, on to which the carbon tube is screwed. The two constituents are insulated from one another by threading the nickel wire through a porcelain tube. The free ends are connected to terminals fitted to a special radiated head, and the whole armoured according to conditions. This armour in most applications consists of a stout seamless steel tube, over which another renewable sleeve is placed. Thus a very strong couple is produced, and as the cost of upkeep is limited to the replacement of the outer sleeves, these elements compare favourably in maintenance cost with other base-metal or alloy couples inserted directly into the hot zone. Even should a junction be allowed to burn away completely, it can be made equal to new at a small cost.

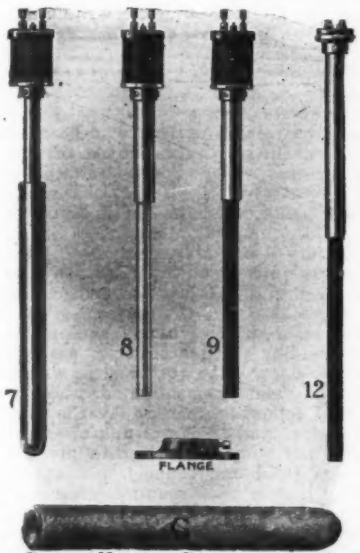


FIG. 1.—CARBON-NICKEL COUPLES AND ACCESSORIES FOR TEMPERATURES TO 1,250 DEG. C. (2,300 DEG. F.). ALSO PLATINUM COUPLE (No. 12).

The Leskole Company, Limited, of Palace Works, Enfield, have just placed on the market a new form of indicator to be used with these carbon-nickel elements. This is shown in Fig. 2, and it will be seen that whilst the body of the instrument is horizontal it is suitable for fixing direct to any wall, and has a scale on which the temperature may be read off conveniently at some distance away. The scale measures 5½ in. in width, and a mirror is provided to prevent errors due to parallax. A feature of this new instrument is that, as shown, the scale need not commence at 0 deg. or room temperature, but may start at some higher figure corresponding to about one-third of the total range. In this way most of the scale is reserved for actual working temperatures, and very open readings are consequently secured. The arrangement includes an auxiliary pointer and a little scale by means of which the zero position of the instrument may be adjusted in accordance with the temperature of the cool or terminal end of the thermo-couple. No battery is used. Although the scale starts at a high temperature, the needle nevertheless gives correct indications of temperature without need for corrections, regardless of what may be the temperature at the cool end of the thermo-couple.

FIG. 2.—HORIZONTAL WALL-PATTERN INDICATOR FOR CARBON-NICKEL AND PLATINUM COUPLES.

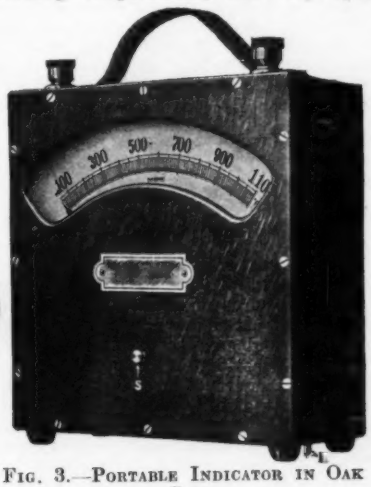


FIG. 3.—PORTABLE INDICATOR IN OAK CASE.

The indicator is of the well-known moving-coil pattern, and has double pivoted jewelled bearings. These are of such sensitiveness that these indicators can be provided with total resistances of 500 ohms. for use in conjunction with carbon-nickel thermo-couples. This is a valuable advantage, as the indicators may be any reasonable distance from the furnaces without interfering with the accuracy of the results, and they may be connected to the couples by cheap copper cable. These pyrometers are particularly recommended for every kind of hardening and annealing furnace, for hot-blast mains, etc.

A similar instrument for lower temperatures is made using iron and constantan for the elements composing the thermo-couple. A new portable indicator shown in Fig. 3 has just been brought out, particularly for temperatures of flue gases and superheat in boiler houses. It will be seen that the pattern is a neat one, the instrument being mounted in polished oak case with handle complete. A locking device is provided by means of which the needle is held rigid and guarded against damage whilst the instrument is being carried. It releases itself automatically as soon as the indicator is placed on a table or the floor.

"F.T.J." Bookshelf.

Fowler's Mechanics' and Machinists' Pocket Book and Diary, 1914.

Edited by Wm. H. Fowler. Manchester: Scientific Publishing Company, 53, New Bailey Street.

A synopsis of practical rules for fitters, turners, mill wrights, erectors, pattern-makers, foundrymen, draughtsmen and others is given in this pocket book. A collection of handy references and tables is followed by sections on materials used in machine construction, machine-tool design, proportions of machine-tool parts, metal-cutting tools, high-speed tool steels, screw-cutting, etc., emery wheels, shop practice, wheel gearing, and a variety of other matters of importance to the machinist and mechanic.

Modern Steel Analysis.

By J. A. Pickard, B.Sc. (Hons. Lond.), A.R.C.Sc., etc. London: J. and A. Churchill, 7, Great Marlborough Street, W.

In a small volume of 128 pages the author has presented a selection of practical methods for the chemical analysis of steel, condensed into as small a space as may be considered practicable. A section on general procedure has also been included to meet the needs of students without experience in chemical practice, and many valuable hints are given therein. All the constituents of steel which are of fairly common occurrence are dealt with in the book, to the number of nineteen, but methods for the estimation of tantalum, columbium, tin, boron and a few other unusual constituents of steel have been omitted. We could scarcely wish for a volume on this subject to be more concise, for no superfluous wording has been indulged in by the author; and this feature should commend it to both students and analysts.

The Microscopic Analysis of Metals.

By Floris Osmond. London: Charles Griffin & Company, Limited, Exeter Street, Strand, W.C.

The first edition of this important work by the late M. Floris Osmond and edited by Dr. J. E. Stead, was reviewed in our columns in 1908. The present edition has been revised and corrected by Mr. L. P. Sidney, Assistant Secretary of the Iron and Steel Institute. The work adheres very largely to the text of the original translation published in 1904, but a number of useful additions are made, including two or three chapters by Dr. Stead. These additions have improved the value of the work to the student, and the second edition will be found even more acceptable than the first to those interested in the microscopic analysis of metals. The translation has been well done, and the illustrations are clear and numerous.

The Sampling and Assaying of the Precious Metals.

By Ernest A. Smith. London: Charles Griffin & Company, Limited, Exeter Street, Strand, W.C.

No more competent author could have undertaken the task of dealing with this subject than Mr. Smith, who was for many years demonstrator in the metallurgical laboratory of the Royal School of Mines, following his father, the late Mr. Richard Smith, who was one of the original teaching staff. Mr. Smith, who is Deputy Assay Master of the Sheffield Assay Office, brings to bear on his subject a vast amount of experience, and it is not too much to say that in his 450 pages he covers the subject very fully. After consideration of the design and equipment of assay offices, including such accessories as balances and furnace implements, the author deals with the valuation, sampling and preparation for assay of precious metal ores, following this up by chapters on the assays of silver and gold ores and of silver and gold bullion. Other subjects dealt with are the assay of base bullion (lead and copper), platinum, and the assay of auriferous and argentiferous metal products. The value of the work is greatly enhanced by an excellent bibliograph, and a large amount of useful information is contained in the appendices. Mr. Smith's book will unquestionably take rank as a standard work.

Fowler's Mechanical Engineers' Pocket Book, 1914.

Edited by Wm. H. Fowler. Manchester: Scientific Publishing Company, 53, New Bailey Street.

This is a useful collection of engineering data. It is divided into sections, which include the following:—Miscellaneous tables and formulæ; steam boiler fittings; fuels and combustion; steam engines; steam turbines; valves and valve gear; internal combustion engines; hydraulics, pumps and pumping arrangements; gearing and lubrication; hoisting and lifting machinery; iron and steel, metals and alloys; springs; chemistry; ventilation and heating.

Newcastle and Gateshead Chamber of Commerce Year Book and Commercial Review.

Edited by Herbert Shaw, B.A., F.R.G.S. Issued under the auspices of the Newcastle and Gateshead Chamber of Commerce.

This year-book and commercial review is a well-illustrated publication of about 250 pages, containing a most useful collection of information regarding the district in question, its industries, facilities, etc. Descriptive accounts of the work of numerous firms in the district form a very interesting feature of the publication.

"DER GIESSEREI BETRIEB" is the name of a new fortnightly journal which has just made its appearance in Vienna, in the interests of the Austrian iron, steel and metal founding industries. It will be the organ of the new Austro-Hungarian Foundry and Foundrymen's Association, which is in course of formation.

Inventions.

Applications for Patents.

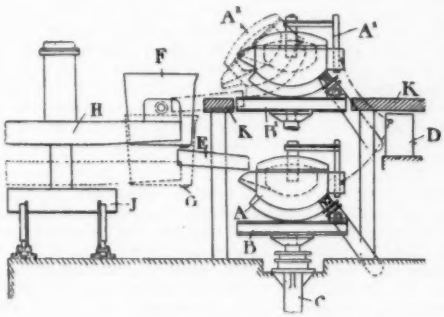
An Asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

5,651.*Siemens-Martin furnaces. Eickworth & Sturm G.m.b.H.
5,664.*Melting-furnaces. I. Hall.
5,824. Machinery for cutting the runners, heads or risers of steel, or iron or other metal castings, etc. W. Livingstone.
5,875 & 5,876.*Reverberatory furnaces. Eickworth & Sturm G.m.b.H.
6,272.*Vibrating-machine for the manufacture of foundry cores. M. Fauquet.
6,349.*Muffle furnaces for the production of zinc. H. Koppers and N. Lengersdorf.
6,768. Furnace linings. W. S. Rawson.
7,238. Muffle furnaces. I. Hall.
7,401. Jigging-apparatus for grading sand. J. Rule.
7,514. Casting ingots. P. R. Kuehnrich.
7,635. Crucible and melting-pot furnaces. L. F. Tooth.
7,636.*Furnaces for melting. L. F. Tooth.
7,917.*Moulding-flasks. (G. F. Dana, United States).
7,927.*Method of mixing metals. W. H. Kelly and P. J. Moran.
8,247.*Hand-operated moulding-machines. H. Rudman, H. T. Lancey, and J. E. H. Craven.
8,270. Alloy of nickel, copper, steel, and aluminium. G. A. Joyce.
8,290.*Core barrel for ingot moulds. J. P. Bagley.
8,291.*Apparatus for making ingot moulds. C. G. Robinson.
8,512 & 8,513. Electric furnaces. J. L. Dixon.
8,638. Gas-heated furnaces. J. King, J. R. Burnett, Richmond Gas Stove and Meter Company, Limited, and A. Mead.
8,740. Regenerator furnaces for use with vertical retorts. Drakes, Limited, and W. A. Drake.
8,955. Furnaces heated by oil fuel for melting metals. J. Ward.

Abstracts of British Patent Specifications recently Accepted.

26,411 (1913). *Furnaces Provided with Regenerative Chambers.* H. Poetter, 126, Grafenberger Allee, Düsseldorf; and the Firm of Poetter, G.m.b.H., Hansahaus, Düsseldorf, Germany.—The claims are:—(1) In a regenerative furnace wherein the direction of the flame remains constant, means for effecting the reversal of the flow of the heated air and of the waste gases through the regenerative chambers, comprising a slide that is provided with three ports, and that moves across the flues leading to the regenerative chambers. (2) In a regenerative furnace, a reversing slide according to claim 1, whereof the outer ports alternately open laterally towards the waste gas flue, whilst the central port is open laterally towards the air flue. (3) In a regenerative furnace, comprising a reversing slide in accordance with the preceding claims, an air flue and a waste gas flue each of which is bifurcated in proximity to the slide, substantially as and for the purpose described. (4) In a regenerative furnace a reversing slide so constructed and arranged that the ports of the slide lead in three directions with the result that the passages for the fresh air, the waste gases and the regenerative chambers are in communication with ports formed in three different faces of the slide. (5) In a regenerative furnace, a reversing slide in accordance with claim 4, wherein two of the faces of the slide are vertical, the ports therein opening in opposite horizontal directions whilst the third face of the slide is horizontal, its port opening downwards to one or other of the regenerative chambers.

29,051 (1912). *Process for the Manufacture of Steel and Apparatus therefor.* Rombacher Hüttenwerke, and J. I. Bronn, both of Rombach i/Lothringen, Germany.—The invention provides an improved process for the manufacture of steel of the type in which the material required for modifying the character of the metal is introduced in a liquid state into the body of metal to be treated. The solid material is dissolved in a bath of molten metal having a composition similar to that of the main body of metal to be treated. In carrying the invention into effect, the additions which it is desired to make to the bath of refined iron for the purpose of de-oxidation, de-sulphurisation, carburation, elimination of gas or alloying, are first dissolved in liquid iron of composition similar to the body of metal to be treated in a separate dissolving furnace, and then the resulting dilute molten iron solution and the refined iron are poured into the casting ladle where they become mixed together. When the refining furnace is so constructed that the slag covering can be removed from the steel bath (for instance in tilting furnaces), the molten iron solution may be added to the steel bath contained in the refining furnace after the slag covering has been removed. For the purpose of making manganese steel according to the improved process, manganese or ferro-manganese is dissolved in the molten iron contained in a dissolving furnace, and the solution is mixed with the charge of refined iron to be treated. In order to make a manganese-carbon steel containing a given percentage of carbon and manganese, the corresponding quantity of carbon is dissolved in the dissolving furnace at the same time as the ferro-manganese. In applying the process to this case, about 1750 kgs. of the molten converter metal are charged whilst liquid into the dissolving furnace, and in it 250 kgs. of ferro-manganese containing 80 per cent. of manganese and also, if required, the desired quantities of carbon, ferro-silicon, etc., are dissolved with the application of heat. The necessary consumption of heat or energy is thus reduced to about one-eighth of that which is otherwise required. As shown, the dissolving furnace A is mounted on the table B supported by the plunger of a hydraulic ram C. The electrical furnace A may be connected by flexible current leads to a transformer D. From the casting ladle F which is mounted on a hydraulic ram H carried by a casting truck J, the liquid iron is run by means of a tapping plug G and channels E into the dissolving furnace A. If desired, the other additional materials which are to be dissolved, may be added at the same time. The furnace is then raised by means of the hydraulic ram C to the level of the working platform K, and when the liquid iron containing the additional materials dissolved in it is required for use, the furnace is tipped and its contents are discharged in whole or in part by means of the channel E into the casting ladle F underneath. The casting ladle with its liquid contents can then be conveyed without loss of time underneath the tapping hole of an open-hearth furnace, or underneath the mouth of a converter for the purpose of receiving its complete charge of iron for casting into ingots.



Improved Steel-Making Plant.

21,158 (1913). *Metal Melting Furnaces.* I. Hall, Exchange Buildings, New Street, Birmingham.—Figure 1 is a plan of the furnace; Figure 2 is an elevation of same in partial section. The melting pot 1 is supported upon the casing 2, completely enclosing the upper end, so as to form a chamber in which is disposed the gas burner 3. Over the melting pot is disposed the dome-shaped cover 4, forming a second chamber above

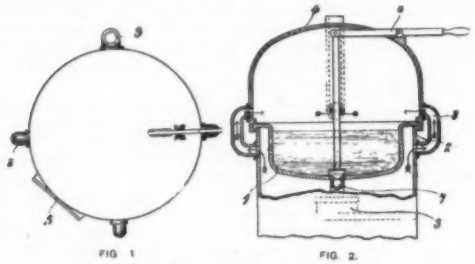


FIG. 1 FIG. 2.

Metal Melting Furnace, by Hall.

the surface of the metal. The metal is charged through a door 5 disposed in the cover 4, and there is an arm 6 arranged to regulate the flow of the molten metal to the pouring spout 7. The connecting pipes 8 are shown leading from the chamber in which the gas burner is located to the chamber above the pot, the flue 9 being disposed at still another point upon the cover, both the pipes 8 and 9 being disposed close above the surface of the molten metal at equal intervals around its periphery. The products of combustion are passed into the periphery of the pot and drawn over the surface of the molten metal on their way to the flue, and any air which passes into the chamber will either be drawn direct to the flue or will form an inconsiderable proportion of the total quantity of gas in contact with the surface of the metal.

9,099 (1913). *Sand Moulding Machines.* Société Anonyme des Etablissements Ph. Bonvillain & E. Ronceray, of 9 and 11, rue des Envierges, Paris; and E. Ronceray, 9 & 11, rue des Envierges, Paris.—The claims are as follows:—(1) A moulding machine for moulding by means of double-faced pattern plates, in which the approaching movement of the boxes and the pattern plate during ramming, pattern drawing and closing is effected by a long stroke piston of small diameter, and the ramming itself effected by a short stroke piston of large diameter mounted on the same axis as the long stroke piston, which comes into action immediately after the first one. The sand mould is pushed out by a piston arranged concentrically with the other pistons, in such a way that when the pressure is admitted to its upper surface a movement in the opposite direction is effected by the short stroke piston and the flasks, after the support of the lower flask comes to rest on the fixed base of the machine. (2) A machine as set forth in Claim 1 in which the respective positions of the lower flask and the ramming disc can be regulated by means of a central screw which supports the flask, a nut on this screw coming to rest against the ramming disc whereby the quantity of sand in the flask can be regulated. (3) A machine as set forth in Claims 1 and 2, in which an upper flask is completely free on the machine, and carries at its upper part a projection for fixing it to the cross-bar for the purpose of removing the pattern, and hooks to fasten it to the lower flask for pushing out the sand mould, which arrangement does away with the necessity for any connection of the upper flask to the machine. (4) A machine as set forth in Claim 1, in which the pattern plate and the upper flask are guided by themselves during the different operations without any guiding device, the upper flask and the pattern plate being completely independent of the machine, the latter resting on its swinging support which remains in place during the ramming and pattern drawing, allowing the lower flask to pass through it to enable the simultaneous ramming of the two flasks.

Trade Talk.

NORTON & GREGORY, LIMITED, have established a branch at 6, Budge Row, London, E.C.

MESSRS. SAVILLE & WALTON have removed to 39, Victoria Street, Westminster, London, S.W.

MESSRS. WARD & GOLDSTONE, of Manchester, have established premises at 50, Wellington Street, Glasgow.

THE JUDSON-JACKSON COMPANY, LIMITED, have opened additional offices at Parliament Chambers, Westminster, London, S.W.

THE MACHINE TOOL AND ENGINEERING ASSOCIATION, LIMITED, have arranged an exhibition at Olympia, from September 28, 1916, to October 18, 1916.

HOWARD AND BULLOUGH, LIMITED, of the Globe Works, Accrington, have erected new foundry buildings, in Charter Street, Accrington.

MR. F. C. THOMPSON has lectured before the Sheffield Society of Applied Metallurgy on "The Microscope in its Relation to the Non-Ferrous Metal Industries."

IN addition to the extensions now nearing completion at the Port Talbot Steel Works, it has been decided to further extend the works by erecting two more furnaces.

AT a meeting of the Birmingham Section of the Institute of Metals, under the presidency of Professor Turner, a paper written by Messrs. Shepherd and Merrick was read on non-ferrous metals.

MR. C. J. STILWELL has become the European agent, with headquarters in London, of the Warner and Swasey Company, Cleveland, U.S.A., in place of Mr. A. C. Cook, who has returned to America as sales manager of the company.

ESCARE & DANELLE, LIMITED, of 129, Wardour Street, London, W., have recently been honoured with the Royal Warrant of Appointment as manufacturers of electrical fittings and bronzes to His Majesty King George V.

AN order was made on March 26, under the Patents and Designs Act, 1907, restoring the Letters Patent granted to Lambton Le Breton Mount for "Improvements in furnaces for melting metals, etc.," numbered 18,417 of 1907, and dated August 14, 1907.

IT is officially stated that the debenture holders of Thornewill & Warham, Limited, Burton-on-Trent, have appointed a receiver on their behalf, and that it is intended to carry on the business with a view to its reconstruction or sale as a going concern.

AT a meeting in Sheffield on April 15 of shareholders in Vickers, Limited, the resolution passed on March 27 increasing the capital by 1,110,000 ordinary shares at 28s. per share was confirmed, the allotment to be one new share for every four existing shares.

THE partnership heretofore subsisting between Messrs. W. Denby and J. Shackleton, carrying on business as wire polishing machine makers and engineers, at 11, Clifford Street, Bradford, under the style of the Bradford Machine Company, has been dissolved.

THE engineering portion of the works of the Thames Ironworks, Shipbuilding and Engineering Company, Limited, will be re-opened very shortly, Mr. W. Defries, who recently acquired that section of the works, having secured ample working capital to commence operations.

AS a consequence of the satisfactory results obtained from the five 50-ton melting furnaces recently built for South Wales steel makers by G. P. Wincott, Limited, of Sheffield, this firm has received an order from Wm. Gilbertson & Company, Limited, of Pontardawe, for one 35-ton open hearth basic steel melting furnace.

THE partnership heretofore subsisting between Messrs. R. P. Wailes and T. C. Skinner, carrying on business as mechanical engineers, at 386 and 388, Euston Road, London, N.W., under the style of George Wailes and Company, has been dissolved. The business will be carried on in future by Mr. R. P. Wailes.

PURSUANT to the Railway and Canal Traffic Act, 1888, the various railway companies of Great Britain and Ireland have applied to the Board of Trade to amend the classification of merchandise traffic and schedule of maximum rates and charges applicable thereto, by adding Cadmium metal to Class 5 of the classification.

THE International Shipping, Engineering and Machinery Exhibition, which will be open from September 25 to October 17, at Olympia, London, W., will be well patronised, as many of the largest engineering firms have already taken space, while the Dutch exhibits will prove an instructive section. The stands will be standardised, no high partitions obstructing the view of exhibits being permitted.

DURING their recent visit to Cheshire, the King and Queen inspected the shipbuilding yards and works at Birkenhead of Cammell, Laird & Company, Limited. Their Majesties were received by Mr. W. L. Hichens (chairman), Colonel William Sidebottom (deputy-chairman), and Mr. G. J. Carter (managing director), and were conducted round the establishment and shown the operations in the numerous departments.

THE co-partnership of Thomas Potter, engineers, etc., 41, Cumberland Street, East, and 364, Abercromby Street, Glasgow, of which Mr. Henry R. Potter, Mr. Thomas Potter, junr., Mr. William R. Potter, Mr. George L. Potter and Mr. William T. Johnston were the sole partners, has been dissolved as at December 31, 1913, by the retirement of Mr. George Laird Potter. The remaining partners will continue the business under the same name.

MESSRS. ALLDAYS & ONIONS, PNEUMATIC ENGINEERING COMPANY, LIMITED, Birmingham, have forwarded their latest list of pneumatic power hammers, drop stamps, etc. Particular mention might be made of their valve gear for striking single dead blows from the top of the stroke, without having to lower the tup on to the work. This contrivance is an important development in the working of pneumatic forging hammers, and extends their sphere of usefulness. The list contains much interesting information.

AT the Leicester Bankruptcy Court H. J. Simpson, engineer and ironfounder, came up for his public examination before Mr. Registrar Deane. The liabilities expected to rank were £3,786, and the assets £8. Debtor stated that he first joined the firm of Messrs. Bill ironfounders, but withdrew some years later, taking out £4,800. In June, 1912, he joined a Mr. Hill in the flotation of the engineering business of Messrs. Death and Ellwood, then carried on by Hill, with a nominal capital of £15,000. He put £3,000 into the company, but lost all his capital in the business, besides becoming responsible for liabilities amounting to nearly £9,000 in connection with the company. The examination was closed.

THE annual meeting of the Manchester Association of Engineers was held on March 28, and, after the business proceedings were over, an address was delivered by Mr. J. C. Maxwell Garnett, Principal of the Manchester Municipal School of Technology, on "The Education of Engineers." Dr. Edward Hopkinson, president of the Association, was in the chair during the early part of the meeting, giving place later to Mr. E. G. Hiller, the newly elected president. The report of the Council showed that the total number of members and associate members on the roll amounted to 646, as against 631 in the year before, and the balance to the credit of the Association amounted to £6,547, compared with £6,296 at the close of the preceding year.

THE CONSETT IRON COMPANY, LIMITED, celebrated their jubilee on April 4. Acquired from its previous owners early in 1864, the establishment was transferred to the new company, registered as the Consett Iron Company, Limited, on April 4, 1864—just half a century ago. There were nine directors appointed—all of whom have died. The first managing director was Mr. J. Priestman; and on his retirement in 1869, Mr. (later Sir) David Dale succeeded to that office, after an association with the works from 1857. Sir David became chairman in 1884, on the death of Mr. John Henderson, whose son became chairman on the decease of Sir David Dale.

NOBLE & LUND, LIMITED, are doubling the area of the large machine shop at their Felling-on-Tyne Works by extending the three bays 150 ft., two of which bays are 54 ft. and one 30 ft. wide. The end wall will be knocked out of the older shop, and the crane runways joined up with the new, two additional 25-ton cranes being installed. Formerly the whole of the material coming to and goods sent from the works had to be carted, which with the heavy class of machine tools the works produce was often a matter of considerable difficulty. The company are, however, just completing a siding to serve the machine shop and the foundry, which will join up with the main line at Felling.

As the result of the deputation which waited upon the Chairman of the Board of Inland Revenue in November last from the Association of Chambers of Commerce of the United Kingdom on the subject of income tax allowances, a conference of Chambers has been summoned to deal with the question as affecting the particular trades referred to. In the meantime a statement, as follows, has been prepared by the Manchester Chamber for the engineering and metal trades:—That 2½ per cent. on the original cost should be allowed as depreciation on buildings; that such parts of buildings as are necessary for carrying shafting, cranes, etc., should be regarded as part of the machinery, and be subject to the same depreciation; that expenses of removal, the cost incurred in the re-arrangement of plant and machinery, formation and legal expenses should be chargeable against revenue. The following scale of allowances per annum for depreciation is recommended: Machine tools (heavy), 5 per cent.; ditto (light or automatic), 7½ per cent.; sprinkler installation, 5 per cent.; engines, boilers, economisers, gas, water and steam pipes, and heating apparatus, 5 per cent.; gas, oil and high speed steam engines and water tube boilers, 7½ per cent.; electrical generators, motors, and electrical plant, including wiring and electrical lighting, 7½ per cent.; patterns (wood and iron), 13½ per cent.; moulding boxes, 10 per cent.; loose tools, templates and jigs, 25 per cent.; fixtures, benches, storeroom and other fittings, 7½ per cent.; office furniture (not including typewriters), 7½ per cent.; typewriters and kindred machines, 20 per cent.; horses, carts, and lorries, 20 per cent.; motor lorries and motor cars, 25 per cent. These percentages are subject to the following reservations:—They should be calculated on the original cost and not on the reducing amount and should it be found impossible to grant this, the suggested rates of depreciation should be correspondingly increased; they are applicable to machinery worked during the usual hours; if worked night and day the percentage should be doubled. Items 7 and 9 only apply when the cost of the articles mentioned has been charged to capital account.

British Foundrymen's Association: London Branch.

Before the London Branch of the British Foundrymen's Association on April 24 two brief lectures were given by Mr. Aitken and Mr. A. Willis respectively. The Branch President, Mr. J. Ellis, occupied the chair. Mr. Aitken discussed a number of practical foundry questions, including the toughening of sand by milling, the use of unvented cores, the casting in of steel screws into castings, the contraction of castings, the segregation of the constituents of cast iron, and the use of "chills" or denseners for obtaining soundness in otherwise spongy parts of castings. Mr. Willis discussed the difficulties involved in the use of scrap metals in the foundry, pointing out first how readily the use of scrap iron could upset all the calculations based on an analysis of the pig-iron used. In the case of non-ferrous metals the case was still worse, for small quantities of unsuspected elements would cause very considerable trouble. The employment of an analyst would, he contended, discount the gain in cost of metal which scrap allowed, and the only practicable method of dealing with the problem was the use of a fine discretion, which usually only resulted from long experience and acquaintence with scrap metals. Interesting discussions followed each lecture, and a number of important points were brought out, one speaker remarking that in his experience scrap iron in the cupola kept the furnace in better working condition and allowed results that could not be got otherwise.

Personal.

MR. J. THOMPSON has been elected president of the Wolverhampton Engineering Society.

THE late Mr. R. G. Evered, managing director of Evered & Company, Limited, of Birmingham, left estate valued at £4,216 gross.

ESTATE of the gross value of £661,757 has been left by the late Mr. J. G. Crompton, chairman of the Stanton Ironworks Company, Limited.

THE late Mr. J. Galloway, jun., of Messrs. Ross & Duncan, engineers, Govan, left personal estate in the United Kingdom valued at £6,008.

THE Council of the University of Sheffield has appointed Mr. Wilfred Jevons, B.Sc. (London), to the post of junior lecturer and demonstrator in physics.

MR. F. W. COOPER, of Crosby, Scunthorpe, Lincs., has been elected managing director of the Partington Steel & Iron Company, Limited, of Irlam, Manchester.

THE late Mr. John G. Cocker, a director of Cocker Brothers, Limited, steel and wire manufacturers, of Sheffield, left estate of the gross value of £54,397, of which £53,944 is net personalty.

THE late Mr. J. Gresham, a director of Gresham & Craven, Limited, engineers, of Salford, Manchester, left estate of the gross value of £461,953, of which the net personalty has been sworn at £443,444.

MR. A. W. TAIT, of London, has been elected to a seat on the board of the Otis Steel Company, Limited, of Cleveland, U.S.A., in place of the late Mr. T. F. Thomson. He will be the chairman of the company.

SIR HUGH BELL, Bart., who has been in the United States, has been the guest of honour at several functions in New York given by Mr. E. H. Gary, chairman of the United States Steel Corporation. On Saturday, March 28, Sir Hugh was the principal guest at a small dinner given by Judge Gary at his residence.

ON the occasion of his retirement from active duty, Mr. John Shepherd, works manager, Ferryhill Foundry, Aberdeen, has been the recipient of a presentation from the officials and men. Mr. Shepherd, in replying, gave some interesting reminiscences of the 44 years he had been in the service of Messrs. James Abernethy & Company.

MR. RENE FLIX has taken up the position with the Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria Street, London, E.C. (British representatives of the Messrs. Bonvillain & Ronceray, Paris), recently vacated by Mons. P. Delalande, and will conduct the business of the company in the Midlands and South of England.

MR. HENRY PHIPPS, formerly one of the partners of Mr. Andrew Carnegie, and one of the leading pioneers of the steel industry of the United States, is retiring from direct connection with the industry. Mr. Phipps has resigned as a director and a member of the Finance Committee, the chief administrative body of the United States Steel Corporation. He has been a member of the board and of the Finance Committee since the Carnegie Steel Company was made a subsidiary of that Corporation in 1901. Mr. J. F. Phipps, his eldest son, will succeed his father as a director of the Corporation.

MR. W. B. GRAHAM has been appointed secretary and treasurer of the John Wilkinson Monument Fund, in place of the late Mr. T. R. Wilson. Arrangements have been made by which the familiar iron monument to the memory of the famous eighteenth century ironmaster is to remain on the Castle Head Estate, Lindale, Grange-over-Sands, to be specially cared for and preserved to posterity. Hitherto the tenure of the site on which it stands has been insecure, but it is now to be legally conveyed and vested in the local authority, with space sufficient to locate the first iron boat in the world, if it can be recovered. It is estimated that altogether a sum of £250 is required for monument site, repairs, and future maintenance. Should there be any surplus, it is intended to devote this to the recovery of the first iron boat now lying in Helton Tarn, or towards a museum of Wilkinson curios.

Deaths.

THE death is announced from Essen, Germany, at the early age of 54 years, of Herr Georg Crucius, the manager of the Ilseder Ironworks. The deceased was one of the pioneers of the movement in favour of the utilisation of blast-furnace gases in Germany.

THE death has occurred of Mr. W. G. Kirkaldy, head of the testing and experimenting firm of David Kirkaldy & Son, 99, Southwark Street, London, E.C. At the age of 21 the deceased gentleman was taken into partnership with his father, and the firm of David Kirkaldy & Son was established.

THE death is announced of Professor J. H. Poynting, F.R.S., the distinguished physicist, at the age of 62 years. The deceased gentleman was educated at Manchester, London and Cambridge, and in 1876 was appointed a demonstrator at Owens College, Manchester. He subsequently accepted a professorship at Mason College, Birmingham, which he held until his death.

MR. WILLIAM BARRACLOUGH, of West View, Farsley, died on April 5. He was the founder of the firm of William Barraclough, Limited, ironfounders, of the Providence and Victoria Foundries, Stanningley, Leeds, but owing to indifferent health he had not taken an active part in the business for some years. He was, however, on the board of directors.

THE death has occurred at Antrim Road, Belfast, of Mr. Thomas F. Shillington, J.P., a director of the iron founding firm of Musgrave & Company, Limited, of that city. He served his apprenticeship to the firm, then of High Street, afterwards of Ann Street, and now of St. Anne's Ironworks, Mountpottinger. He rose step by step by his keen business ability and through his exertions the prosperity of the firm largely increased.

Parliamentary.

M.P.'s and Trading Concerns.

MR. W. THORNE asked the Prime Minister, in the House of Commons, on March 30, whether he would have a return made giving a list of present members of the House of Commons who are members of the board of directors and shareholders of the following companies, viz.:—Armstrong, Whitworth & Company, John Brown & Company, Nobels Explosives Company, Harland & Wolff, Thomas Firth & Sons, Coventry Ordance Company, William Beardmore & Company, Cammell, Laird & Company, and Vickers.

MR. ASQUITH: Lists of the directors and shareholders of the companies referred to are open to inspection at Somerset House. The preparation of the return would involve a considerable amount of work, and, as the information desired is already available, I trust my hon. friend will not press to have the return made.

Harvey United Steel Company.

MR. F. HALL asked the First Lord of the Admiralty on March 30, the value of work entrusted by the Admiralty, in each of the three years ended December 31, 1913, to firms connected with the Harvey Steel Trust; and whether the contracts relating thereto were given as the result of open tender.

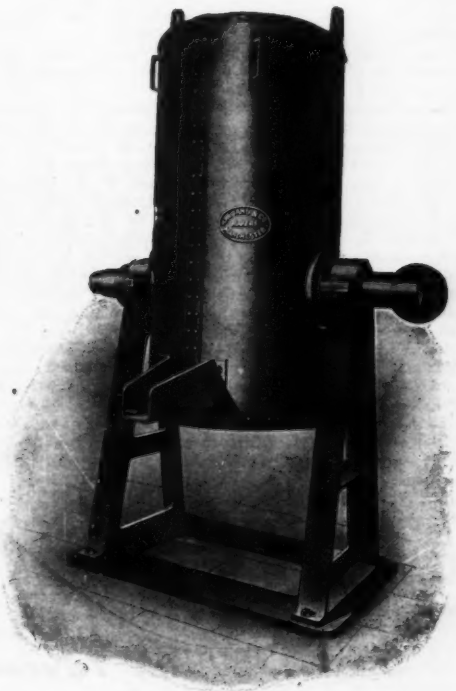
MR. CHURCHILL: I presume the hon. member refers to the Harvey United Steel Company, which was founded in 1901 to acquire the assets relating to the use of certain patent rights for treatment of steel. The Harvey patents expired in 1905, and other patents owned by the company expired in 1909, and royalties lapsed from those dates. From public information it would appear that the company began to return its capital in 1905, and, apparently, was wound up voluntarily in 1912. No Admiralty contracts for the three years referred to by the hon. member appear to have been subject to any royalties on licenses granted by the Harvey Company.

AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
COLONIES, AND FOREIGN GOVERNMENTS.

THE Cupola.
Evans's Rapid.

Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.



James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

New Companies.

J. CHRISTOPHER & SONS, LIMITED.—Capital £4,000 in £1 shares, to carry on the business of mill furnishers, etc., and to adopt an agreement with J. Christopher. The first directors are J. Christopher and C. R. Barry (both permanent joint managing directors). Registered office: 39-43, Clerkenwell Road, E.C.

SOLECTRIC COMPANY, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of engineers, manufacturers and repairers of, dealers in and agents for, machinery, etc. The first directors are J. C. Watson (chairman), C. P. Wall and W. Cowderoy (all permanent). Registered office: 7, Gloucester Road, Brighton.

ETNA IRON AND STEEL COMPANY, LIMITED.—Capital £25,000 in £1 shares, to acquire and carry on the business of the Etna Iron and Steel Company, Craigneuk, Motherwell. The first directors are J. Kerr, W. Cunningham, and J. Kerr, jun. Registered office: Etna Iron and Steel Works, Motherwell.

WALTER GRAFTON & SON, LIMITED.—Capital £3,000 in £1 shares, to take over the business of engineers, metal workers, and merchants, etc., and to adopt an agreement with Walter Grafton. The first directors are W. P. Grafton and Mrs. A. C. Grafton. Secretary, F. Head, 159, Edgware Road, London, W.

BRITISH BONTEMPI RUST-PROOFING COMPANY, LIMITED.—Capital £3,550 in 3,400 preference shares of £1 and 3,000 deferred shares of 1s., to carry on the business of rust-proofers, proprietors of rust-proofing furnaces and appliances, etc. The first directors are T. Thompson and R. Colgate. Registered office: 23, St. Swithin's Lane, London, E.C.

VINCENT PUMP AND TRANSMITTER COMPANY, LIMITED.—Capital £15,000 in 5s. shares, to carry on the business of mechanical, electrical, and general engineers and contractors, etc., and to adopt an agreement with the Roto-plunge Pump Company, Limited. The first directors are J. Hibbert, H. T. Box, L. Morgan, W. H. Taylor, H. A. Moore, and J. Brown-Martin.

JOHN ROBY, LIMITED.—Capital £20,000 in £1 shares, to take over the business carried on by T. S. Roby and W. H. Roby, at Rainhill, Lancashire, as John Roby, and to carry on the business of engineers, brass and iron-founders, etc. The first directors are T. S. Roby and W. H. Roby. Registered office: Brass Foundry, New Road, Rainhill, near Liverpool.

THOMAS L. HALE, LIMITED.—Capital £5,000 in £1 shares (1,000 preference), to carry on the business of malleable and general ironfounders as formerly carried on by T. L. Hale in Hatherton Street, Walsall, and that of toolmakers, engineers, metal workers, etc. The first directors are T. W. Hale, T. L. Hale, and W. E. Hale. Registered office: Hatherton Street, Walsall.

HELICAL ROLLERS, LIMITED.—Capital £12,000 in £1 shares, to take over the business of Messrs. Wright, Midgeley & Davies, to acquire patents for inventions relating to the manufacture of helically-constructed metal tubing, and to the manufacture of double helical metallic tubing, and to carry on the business of ironfounders, engineers, etc. The first directors are T. A. Judge, A. Midgeley, W. Wright, H. J. Davies, and A. Rigby.

FANS AND BLOWERS AND OTHER FOUNDRY MACHINERY FOR SALE.

BARGAINS FOR PROMPT CASH.

No. – Root's Blower "Acme" for 20 smiths' fires.
One ditto, with high-speed Vertical Engine combined.
Thwaites Roots Blower, 11½" discharge.
"B" Roots Blower by Alldays.
Foundry Blowing Fan, 36" impeller, 19" discharge, also 9½" round outlet to fit on same.
14" Schiele patent Blast Fan.
Lloyd's patent Blowing Fan for 50 smiths' fires.
New Roots pattern Blower, 5".
Silent Blowing Fans, 8½", 8" and 9" discharge.
Ball Mill, with drum, 2' 7" and 5' 8" outside by 1' 7" wide.
Improved Foundry Core Ovens, portable type and for fixing in wall.
4' 6" diameter UNDERGEARED LOAM MILL, with stationary pan.

CHARLES D. PHILLIPS,

EMLYN & CENTRAL ENGINEERING WORKS, NEW ORT, MON.

BLOFIL

THE

IRON CEMENT

(Quick or slow setting grades)

IS

THE CHEAPEST

AND

MOST RELIABLE

for all purposes.

Unaffected by oil, steam, or water.

Sole manufacturers—

RUDD & OWEN

(DEPT I)

Telegrams "Theripnene," Hull.

HULL

Telephone National 1223.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

TRADE SIROCCO MARK

CUPOLA FANS.

Made in eight sizes from 10-in. to 35-in. diameter, and suitable for melting ½ to 20 tons per hour at pressures from 12—30 inches Watergauge.

Cast Iron Casings and Ball Bearings.

Double Inlet. All Types of Discharge.

Write for Bulletin No. 2028F.

DAVIDSON & CO., LIMITED,

Sirocco Engineering Works,

BELFAST.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time. We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

Telegraph : ELDER, CARDIFF. Telephone : 4640 and 4641.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining on the first day of the current month.

Pig-Iron.

Cleveland.

	s.	d.
Cleveland No. 1	54	3
,, No. 3	51	9
,, No. 4 foundry	51	6
,, No. 4 forge	51	0
,, Mottled	50	9
,, White	50	9
East Coast hematite, mixed Nos.	61	9
Cleveland warrants	51	4½

Above prices are for early f.o.b. deliveries, and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers cash prices.

Scotland.

	s.	d.
Standard Foundry (Glasgow Market settlement price)	51	0
Warrants, ditto	57	4½

Makers' prices:—	s.	d.		s.	d.
Gartcherrie No. 1	68	6	No. 3	63	6
Coltness No. 1	—		No. 3	—	
Summerlee No. 1	68	6	No. 3	63	6
Langloan No. 1	68	6	No. 3	63	6
Calder No. 1	68	6	No. 3	63	6
Clyde No. 1	68	0	No. 3	63	0
Carnbroe No. 1	66	6	No. 3	62	6
Monkland No. 1	62	0	No. 3	60	6
Shotts No. 1	68	6	No. 3	63	6

(All deliverable alongside Glasgow.)

Glengarnock	No. 1	71 0	No. 3	66	0
Eglinton	No. 1	62 0	No. 3	61	0

(All deliverable alongside Ardrossan.)

Dalmellington	No. 1	63 0	No. 3	61	0

(Deliverable alongside Ayr.)

Carron	No. 1	69 0	No. 3	64	0

(F.a.s. Grangemouth.)

Lancashire.

	s.	d.	s.	d.
Lancashire No. 3 foundry f.o.t.	—		56	0
Lincolnshire No. 3 foundry	56	6	57	0
Derbyshire No. 3 foundry	57	0	57	6
Staffordshire No. 3 foundry	—		57	6
Cleveland No. 3 foundry	60	0	60	8

(All delivered equal Manchester.)

Scotch No. 3	Gartcherrie	68	0	68	6
	Glengarnock	65	6	70	0
	Eglinton	—		64	0
	Summerlee	—		67	0

(Delivered Manchester Docks.)

North-West of England.

	s.	d.	s.	d.
Bessemer mixed numbers net f.o.b.	64	3	65	0
Hematite warrant net cash	—		61	0
Lorn cold-blast charcoal iron	—		200	0

The Midlands.

		s.	d.	s.	d.
Staffs.	Common forge	50	0	51	0
	Part Mine forge	51	0	52	0
	Best All Mine	85	0	90	0
	Cold Blast	—		125	0

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

Northampton foundry	—		59	0
North Staffs. foundry	61	0	62	0
Derby foundry	58	0	59	0
Nottinghamshire foundry	66	0	67	0
Leicestershire foundry	—		59	0
Shropshire Cold-Blast	—		125	0

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s.	d.	s.	d.
Forge	50	6	51	6
Grey forge	50	6	51	6
Basic	51	6	52	6
No. 3 foundry	51	6	52	6
No. 4 foundry	51	0	52	0

F.o.t. Makers' works.

South Wales.

	s.	d.	s.	d.
Welsh Hematite	67	0	67	6

Ferro-Alloys.

Net, Delivered Sheffield Steel works.

	£	s.	d.	£	s.	d.
Ferro-chrome: 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	21	0	0			
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	19	0	0			
Ferro-chrome: 8/10% carbon. Basis 60%, scale 8s. 6d. per unit. Per ton	17	15	0			
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 22s. per unit. Per ton	49	15	0			
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	0	10	0			
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit Per ton	11	0	0			
Ferro-titanium: 15/18%, per pound, flat	0	0	6¼			
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained	0	10	9			
Ferro-phosphorus: 20/25%. Per ton	13	10	0			
*Ferro-manganese 80%	9	0	0			
,, export	8	5	0	8	10	0

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£	s.	d.	£	s.	d.
Columns (plain)	7	7	6	to 7	12	6
Pipes, 1¼ to 2½ in.	6	5	0	6	10	0
,, 3 to 4 in.	5	17	6	6	0	0
,, 5 to 8 in.	5	12	6	5	15	0
,, 10 to 16 in.	5	15	0	—		
,, 18 to 24 in.	5	15	0	—		
Chairs	4	5	0	4	6	0
Floor plates (open sand)	3	10	0	3	12	6

(At works.)

Non-Ferrous Metals.

Copper.

	£	s.	d.
Standard Cash	63	11	3
Three months	63	16	3
Electrolytic	65	15	0
Tough	68	5	0
Best selected	63	5	0

Tin.

	£	s.	d.
Foreign Straits Cash	154	10	0
,, ,, Three months	156	10	0
English Ingots	156	0	0
Bars	157	0	0
Refined	159	10	0

Spelter.

	£	s.	d.
Silesian	21	10	0
Specials	22	7	6
Hard	18	0	0
British	22	0	0

Lead.

	£	s.	d.
Soft foreign	18	12	6
English	18	17	6

Antimony.

	£	s.	d.
Regulus	28	10	0

Aluminium.

	£	s.	d.
Virgin Metal, 98/99% per ton	85	0	0

*Chromium (Metallic).

	s.	d.		s.	d.
98/99% purity per lb.	2s. 4½d		to	0	2	6

*Nickel.

	£	s.	d.
In cubes, 98/99% purity Per ton	169	0	0

*Tungsten Metal.

	s.	d.
96/98% purity per lb.	0	2	5

*Molybdenum Metal.

	s.	d.		s.	d.
96/98% purity per lb.	10s. 6d.		to	0	11	0

*Cobalt Metal.

	s.	d.		s.	d.
97% purity per lb.	6s. 9d.		to	0	7	0

Quicksilver.

	£	s.	d.
75 lb. bottle	7	0	0

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.		s.	d.
Steel scrap, heavy melting	46	0	to	48	0
Iron scrap cast (cupola metal)	53	0		55	0

London (f.o.b.).

	s.	d.
Heavy steel	47	0
Light ,,	35	0
Heavy cast	48	6

Non-Ferrous Scrap.

London merchants quote, delivery free, and subject to market fluctuations:—

	J. B. Garnham and Sons. £	s.	d.	A. Joseph. £	s.	d.
Brass	40	0	0	41	0	0
Clean copper	60	0	0	58	0	0
Brasiery copper	55	0	0	52	0	0
Old lead	17	0	0	17	10	0
Tea lead	—			16	0	0
Old zinc	15	10	0	16	0	0
Hollow pewter	115	0	0	110	0	0
Black pewter (shaped)	75	0	0	73	0	0
Gun metal	53	0	0	53	0	0
Aluminium (cast)	—			—		
,, (cuttings)				60	0	0

Stocks.

Pig-Iron in Public Store.

	May 1. Tons.	Inc. + or Dec. − since May 1, 1913. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes	2	−88
Connal's at Middlesbrough	96,537	− 118,116
Connal's at Middlesbrough hematite	—	No change.
West Coast hematite	8,093	−17,979

Metals.

Copper, Europe and afloat	29,853	−15,975
Tin, London, Holland, U.S.A. and afloat	17,074	+6,260

Coke.

Middlesbrough.

	s.	d.		s.	d.
Gas Coke	—		to	12	0
Foundry Coke	—			20	0
Furnace coke	—			17	3

Newcastle-on-Tyne.

	F.o.b. Dunston. s.	d.
FOUNDRY COKE—		
Original Garesfield	20	0
Mickley	20	0
Stella Garesfield	20	0
Priestman's Garesfield	21	0
Consett Garesfield	20	0
Newcastle gas coke	13	0

Cardiff.

	s.	d.		s.	d.
Special foundry coke	25	0	to	27	0
Foundry coke	20	0	to	23	0
Furnace coke	17	0	to	19	0

Leeds.

	s.	d.	
Furnace coke	10	9	at ovens.

Birmingham.

	s.	d.		s.	d.
Foundry coke	31	0	to	37	6
Furnace ,,	17	6	to	20	0
Gas ,,	14	0	to	15	0

Glasgow.

	s.	d.		s.	d.
Foundry coke	25	0	to	27	0
Furnace ,,	17	6		18	6
Gas ,,				0	0

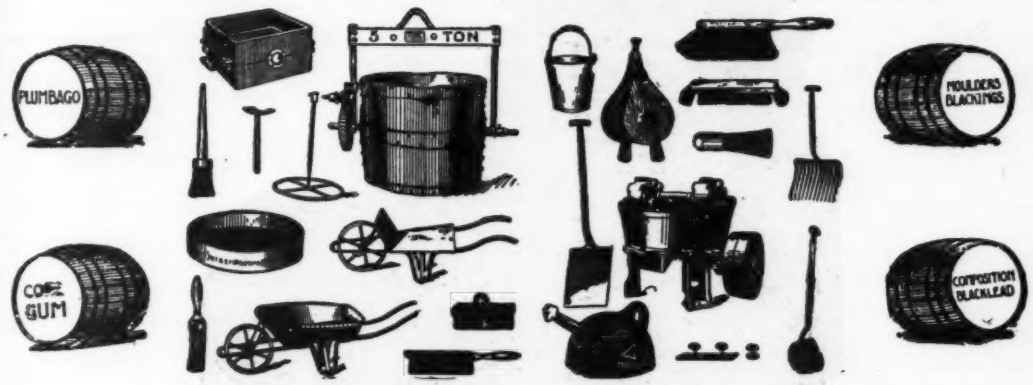
London.

	s.	d.
Foundry coke	—	
Gas ,,	19	2

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



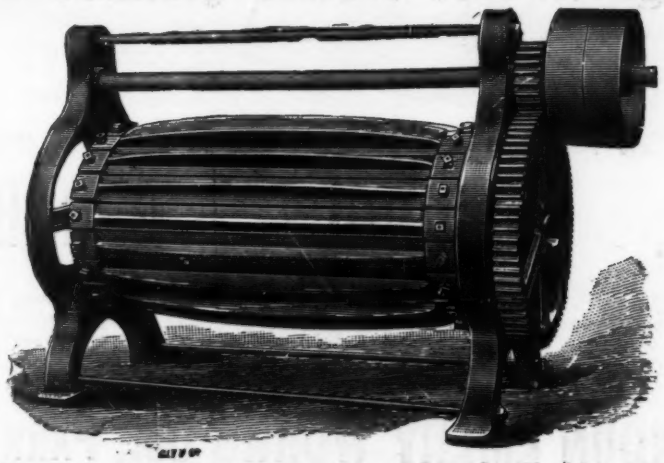
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



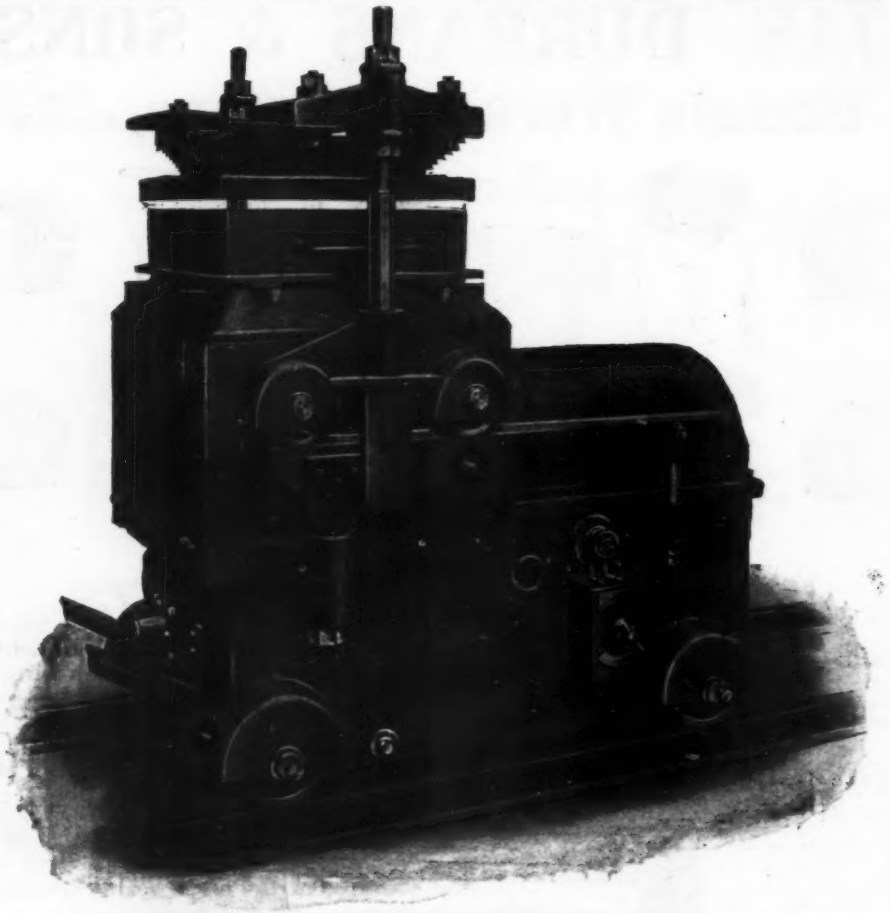
These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

USE YOUR ELECTRIC POWER FOR MOULDING.



THE NEW PORTABLE ELECTRICALLY-OPERATED MOULDING MACHINE.

SPEED. ACCURACY. DURABILITY.

No sand frame required. Strickling of surplus sand from moulding box done away with. The man fills the box with sand, pulls over rammer head and depresses treadle — the electric motor does the rest. There is no faster or simpler machine made. Let us quote for a machine to suit your requirements; a blue print or sample casting is all that we require.

THE LONDON EMERY WORKS Co., PARK WORKS,

TOTTENHAM, LONDON, N.

Nearest Passenger Station, Park, G.E.R. Telephone: Tottenham, 158.

SITUATIONS VACANT AND WANTED.

YOUNG MAN, with 12 years' experience of Foundry work, and 1 year's travelling experience in the Midlands, would like a berth as Midland Counties REPRESENTATIVE with a Firm of Foundry Requisite Manufacturers, on salary and commission. Expenses very low, as advertiser has own motor cycle.—First-class references on application to Box 508, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOREMAN MOULDER wanted. Must be accustomed to heavy Iron Machine Castings, in Loam, Dry, and Green Sand. Non Union man preferred.—Apply, stating age, experience, wage required, with references, to Box No. 512, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

PATTERNMAKER.—Experience in Gas and Steam Blowing and Generating, Marine Engines, Iron and Steel Works Plant, Pumps, Brasswork, Pipes, Millwrighting, Expert Toothed Gearing. Well up in Drawing, Foundry Practice. Five years Foreman. Age 40. Refs.—Box 510, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE AND WANTED.

CORE GUM. ROSIN. CORE GUM. ROSIN.

IT will Pay you to write me for Samples and Prices. EDGAR KENYON, Direct Importer.

5, Carr Street, Blackfriars Street, Manchester.

HALL'S INVINCIBLE SAND MIXERS are now successfully in use for preparing NEW SANDS and UTILIZING OLD SANDS in some of the LARGEST FOUNDRIES.—Write for information and prices to C. E. V. HALL, Stirling Chambers, Sheffield.

TO BRASS FOUNDERS AND OTHERS.—For SALE, almost new HAND MOULDING MACHINE, SAND MILL, ROTARY SIEVE, First-Class GAS ENGINE, LATHES, and other Machines.—Apply Box 490, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London W.C.

TO BUSINESS MEN.

The Decentralisation of Industrial Labour.

The opportunities offered by certain Provincial Towns to Manufacturers requiring to **remove their works** or to **establish new factories or warehouses** are dealt with in detail in a new publication, **"Industrial Progress,"** which may be obtained gratis, at G.N.R. Stations and Offices, or post free from the Superintendent of the Line, Dept. 13, G.N.R., King's Cross Station, London, N.

NAISH & CROFT,

Consulting Metallurgists and Analytical Chemists.

— SPECIALISTS IN FOUNDRY WORK. —

Laboratory for all kinds of Metallurgical Investigations.

ANALYSES. MICROGRAPHS. MECHANICAL TESTS.

When you have trouble write us. Fees on application.
Special Terms for Contract Work.

Address : **150, ALMA STREET, BIRMINGHAM.**

London Office : 9 & 10, Fenchurch Street.

FOR A PERIOD OF OVER TWENTY-FIVE YEARS THE REPUTATION OF

FRODAIR SPECIAL PIG-IRONS

has been steadily growing. Their excellence is acknowledged and acclaimed by leading Engineers and Ironfounders, because they are easily **MELTED, CAST** and **TOOLED,** ensure **REGULARITY** and remarkable **DURABILITY,** and shew genuine **SUPERIORITY** and **ECONOMY.**

CYLINDERS, ENGINE PARTS, VALVES, ROLLS (chilled and grain), HYDRAULIC WORK, FIRE AND ACID-RESISTING CASTINGS, MALLEABLE CASTINGS, and other important work *shew a marked improvement when cast with* **FRODAIR IRONS.**

Write for further particulars, etc.,

THE FRODAIR IRON & STEEL Co., LTD.,

FENCHURCH HOUSE, LONDON, E.C.

Telegrams: "Frodair, London."

WHITE METAL LETTERS

Stamped Brass Letters.

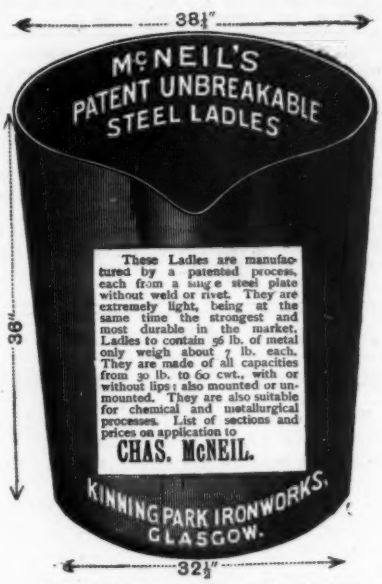
All kinds of Letters for Pattern-making and Foundries supplied from stock at very advantageous prices.

Solid (cast) Brass Letters.

Walton & Co.,

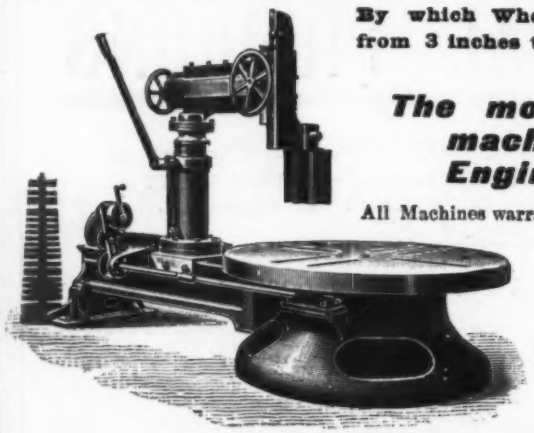
66-68, Slaney Street,

Birmingham.


38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
38"
KINNING PARK IRONWORKS,
GLASGOW.
32½"

Can also be made in Aluminium.

WHITTAKER'S IMPROVED MOULDING MACHINE



By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.

The most complete and efficient machine hitherto introduced to Engineers.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, ***OLDHAM.***

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
326	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	28 Victoria
427	Braby, F. & Co., Ltd.	Petershill Road, Glasgow	Braby, Glasgow	—
321	Bradley, T. & I., & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
331	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
321	British Aluminium Co., Ltd.	109, Queen Victoria Street, E.C.	Cryolite, London	4315 London Wall
422	British Binderit Co., Ltd.	317, High Holborn, London, W.C.	Bindercomp, Holborn, London	950 Holborn
425	Brinck & Hübner	Mannheim, Germany	—	—
C. iv.	Buckley & Taylor, Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
336	Critchley Evans & Co.	Carlton House, Regent St., London, S.W.	Advance, Piccy, London	8052 City
330	Cumming, William, & Co., Ltd.	Maryhill, Glasgow	Prudence, Glasgow	P. O. M. 25
418	Davidson & Co., Ltd.	Belfast	Sirocco, Belfast	4341 Belfast
319	Davies, T., & Son	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
421	Durrans, Jas., & Sons.	Penistone, nr. Sheffield	Durrans, Penistone	—
C. ii.	Dyson, J. & J.	Sheffield	Dyson's, Stannington	702 Sheffield
419	Elders' Collieries, Ltd.	Cardiff	Elder, Maesteg	10
338, 339, 340 & 415	Evans J., & Co.	Manchester	Ladles, Manchester	2297
C. ii.	Everitt & Co.	40, Chapel Street, Liverpool	Persistent, Liverpool	1134 Central (3 lines)
423	Frodair Iron & Steel Co., Ltd.	5, Fenchurch Street, E.C.	Frodair, London	—
C. ii.	Fyfe, J. R. & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
328	Glasgow Patent Moulders Blacking Co.	26, Fleming St., Port Dundas, Glasgow	Moulders, Glasgow	—
318	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs	—
328	Gray, Thomas, E., & Co.	71, Lincoln's Inn Fields, Kingsway, London, W.C.	Papplewick, London	1193 City
C. ii.	Hall, John, & Co. (Stourbridge), Ltd.	Fire Clay Works, Stourbridge	Hall, Stourbridge	55 Stourbridge
425	Hawkins, W. T. & Co.	Huddersfield	Hawkins & Co., Huddersfield	993 Huddersfield.
329	Herbert, Alfred, Ltd.	Coventry	Lathe, Coventry	860 Coventry
335	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
337	Keith, James, & Blackman, Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn(4lines
426	King Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
331	Kuhnle, Kopp & Kausch	Frankenthal-Pfalz, Germany	—	—
322 & 323	London Emery Works Co., Ltd.	Park, Tottenham	Naxium, London	99 Tottenham
417	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
426	Mansfield Sand Co., Ltd.	Mansfield	—	—
428	Marshall, H. P., & Co.	Leeds	Specialty, Leeds	1909 Leeds
—	Metalline Cement Co	112, Bath Street, Glasgow	Adhesive, Glasgow	201Y2 Douglas
417	McGowan, Wild & Co.	206, Lower Hurst Street, Birmingham.	"Logic, Birmingham"	1816 Mid.
325	McLain's System	710, Goldsmith Bldg, Milwaukee, U.S.A.	—	—
424	McNeil, Chas.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
334 & 335	Murphy, Stedman & Co., Ltd.	180, Gray's Inn Road, London, W.C.	Murphites, Holb., London	4628 Holborn
423	Naish & Croft	141, Whitehead Road, Aston Manor	—	—
426	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
417	Phillips, Charles D.	Newport, Mon.	Machinery, Newport	—
C. iii.	Phillips, J. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
425	Pickles, James, Ltd.	Laurel St., Leeds Rd., Bradford	Pickles, Laisterdyke	3723 Bradford
320	Piftin, Ltd.	2, Fen Court, Fenchurch Street, E.C.	Russesco, London	11230 Central
426	Portway, Chas., & Son	Halstead, Essex	Portway, Halstead	10 Halstead
328	Proctor Bros.	Call Lane, Leeds	—	227 Leeds
417	Rudd & Owen	Hull	Therpinene, Hull	1223 Nat.
427	Safety Tread Syndicate, Ltd.	15, Barbican, London, E.C.	—	—
333	Samuelson & Co., Ltd.	Banbury	Unslipping, London	3219 London Wall
328	Silversteen, W., & Co.	147, Cannon Street, London, E.C.	Samuelson, Banbury	—
317	Standard Sand Co., Ltd.	Mansfield	Ottolocos, London	8630 City
321	Stewart, D., & Co., Ltd.	London Road Iron Works, Glasgow	Standard Sand Co., Mansfield	201 Mansfield
C. iii.	Tilghman's Patent Sand Blast Co., Ltd.	Broadheath, nr. Manchester	Stewart, Glasgow	71 P.O. Bridgton & 3243 Bridgton (N)
332	Thwaites Bros., Ltd.	Bradford	Tilghmans, Altrincham	14
324	Universal System of Machine Moulding and Machinery Co., Ltd.	97, Queen Victoria St., London, E.C.	Thwaites, Bradford	3459&3460 Br'd'f'rd
27 & 42	Walker, I. & I.	Rotherham	Machimould, London	2243 City
424	Walton & Co.	53, Newton Street, Birmingham	—	—
424	Whittaker, W., & Sons, Ltd.	Oldham	Walco, Birmingham	Central 3305
331	Wilkinson, Thos., & Co., Ltd.	Middlesbrough	Whittakers Engineers, Oldham	83
427	Williams, J. (Birmingham Sand), Ltd	Birmingham	Blacking, Middlesbro'	419
331	Witting Bros., Ltd.	49, Cannon Street, London, E.C.	—	—
426	Woodward & Copelin	17, Bird-in-Bush Road, Peckham, London, S.E.	Witting, Cent., London	8776 & 8777 City
			—	1882 New Cross

MANSFIELD MOULDING SAND.

Our "SPECIAL" brand as Shipped and Supplied only by us to all parts of the World, for Castings of Iron, Brass, Aluminium, &c. Needs no Grinding or Milling, and is ready for the Moulder.

WRITE STATING CLASS OF WORK TO

The Standard Sand Co., Ltd.,

Mansfield, NOTTS.

Goldendale Cylinder Pig Iron.

MAKERS:

GOLDENDALE IRON Co.,

TUNSTALL, STOKE-ON-TRENT.

Special FOR GAS AND OIL ENGINE LINERS - -

Our Mottled and White .. Cylinder Pig Irons ..

ARE

Absolutely sound and homogeneous

AND

Melt hot and Fluid.

AND

Though extremely hard will machine with ease

AND

Will Cool like Grey Iron leaving no cavity.

CONTRACTORS TO THE ADMIRALTY, COLONIAL GOVERNMENTS, AND OTHER GOVERNMENT CONTRACTORS.

Selling Agents—

WESTOBY & RAWSTRON, 224, Corn Exchange Buildings, Hanging Ditch, Manchester.

FOUNDRY CUPOLAS, LADLES.

And the

OSBORN'S PATENT CUPOLA SPARK ARRESTER.

Are the Specialities of

T. DAVIES & SON,

RAILWAY WORKS, WEST GORTON, MANCHESTER.

ON ADMIRALTY LIST.

Telegrams—"TUYERE, MANCHESTER." Nat. Telephone—No. 70, OPENSHAW.

London Agents: Murphy, Stedman & Co., Ltd., 180, Gray's Inn Road, London, W.C.

PIFTIN

System of Renovating Foundry

SAND

will give you sand at about

1/5th

THE COST

Of what you now Pay.

For full particulars apply— Telegrams: "RUSSESCO, LONDON." — Telephone: No. 11230 CENTRAL.

PIFTIN LIMITED.

2, FEN COURT, FENCHURCH STREET, LONDON. E.C.

W

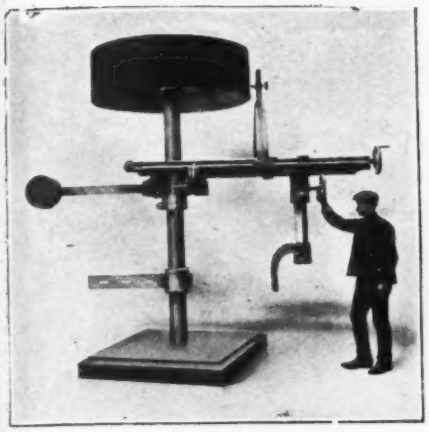
ALUMINIUM for PULLEYS.

Light Pulleys, to Reduce Momentum and Lessen Wear on Belts,
are readily cast in B.A. Aluminium Alloys.

Pulleys Leaflet free from—

Trade Mark.

THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria Street, London.



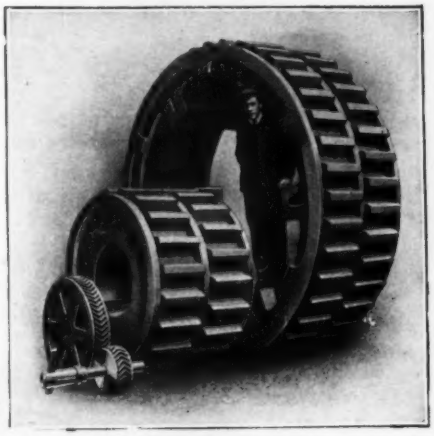
Standard Wheel Moulding Machine.

ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed



Wheels Moulded by this Machine.

No Loose Parts Liable to be Lost.

ACCURATE. PORTABLE. CHEAP.

WRITE FOR PRICE AND PARTICULARS TO

DUNCAN STEWART & CO., LTD.

LONDON ROAD IRONWORKS, GLASGOW.

T. & I. BRADLEY & SONS, LTD.,

COLD BLAST PIG IRON

PIG IRON BRANDS

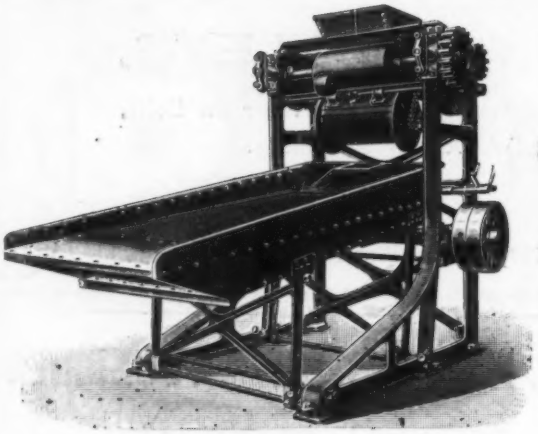
PART MINE. ALL MINE.

WARM AND COLD BLAST. IXL. A M

TO GUARANTEED ANALYSIS.

DARLASTON BLAST FURNACES,

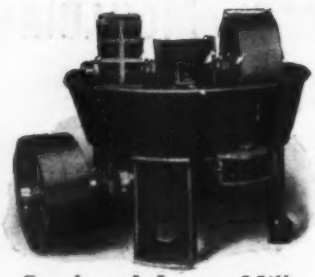
DARLASTON, SOUTH STAFFS.



Sand Preparing Machine fitted with Rollers for crushing the lumps.

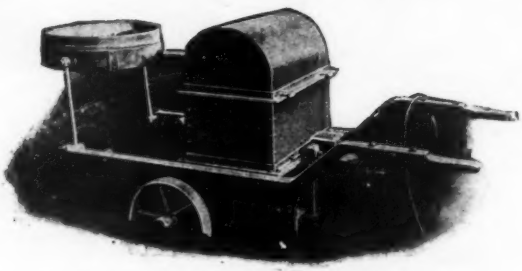
Magnetic Separator and Sifter.

Made in three sizes, with capacity from 3 to 14 tons per hour



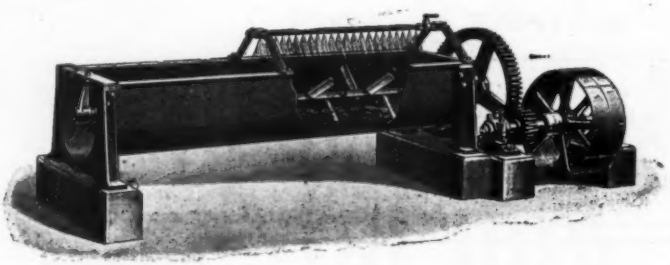
Sand and Loam Mill.

3 Types Sizes 3ft. to 9ft.



Portable Electric Sand Sifter.

Takes only ½ Unit when fully loaded, and will sift all a man can shovel into it.



Batch Mixer for Moulding and Core Sands.

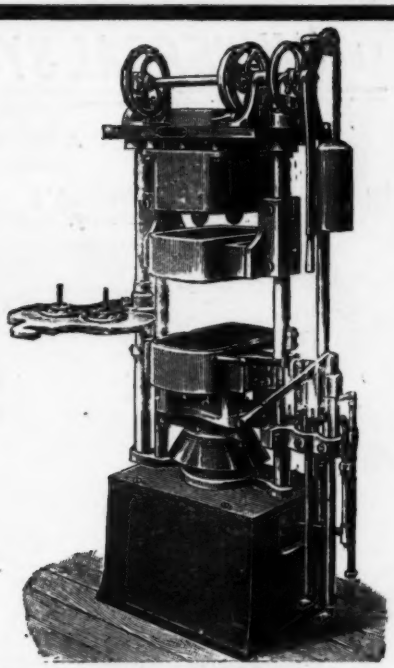
Several Types, Capacities from ½ gall. upwards.

THE LONDON EMERY WORKS Co., PARK WORKS,

TOTTENHAM, LONDON, N.

Passenger Station, Park, G.E.R. Telephone: Tottenham, 153.

Electrically-operated Moulding Machine.
Portable and Self-contained.



Hydraulic "Boxless" Moulding Machine.

Hand-Ramming Turnover Machine.
Pattern "G.H."

This machine is one that possesses immense advantages over other machines for the following reasons:

1. **It has the largest capacity of all known machines.**
2. **It entirely dispenses with moulding boxes and produces the mould ready for casting.**
3. **The machine makes a complete mould from a pair of pattern plates in one operation.**

The large number of these machines installed during the last few years proves their superiority and to give an instance of the capacity of the machine we would mention that two men working this machine for moulds 16″ × 12″ have laid down 60 moulds an hour.

Did you see the machine working at Rugby?

THE LONDON EMERY WORKS Co., PARK WORKS,
TOTTENHAM, LONDON, N.

Passenger Station, Park, G.E.R. **Telephone: Tottenham 158.**

The UNIVERSAL SYSTEM of MACHINE MOULDING

AND MACHINERY CO., Ltd.

97, Queen Victoria St., London, E.C.

PH. BONVILLAIN & E. RONCERAY'S
Patents for Moulding Machinery.

D. F. 4 Moulding Machine.

Why not Increase your Output and Reduce your Cost ? This is only one of our Machines by which you can do this. It enables the pouring without boxes (no snap flask arrangement). One man can work it and turn out easily 30 complete moulds an hour,

SEMI-STEEL CASTINGS,

Containing 20 to 30% Steel Scrap,

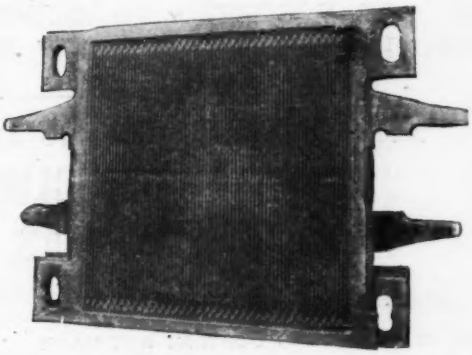
made following

McLAIN'S SYSTEM

Mixing Irons, Semi-Steel, Cupola Practice.

The Wisconsin Foundry Company, Milwaukee, Wis., made for the Falk Company of that city, 500 of these complex castings—the water-jacketed cylinder and engine base being cast in one piece of metal. They ranged in size from 200 to 800 pounds. They used 20 to 30 per cent. steel scrap.

Only 4 were returned—less than 1 per cent.



The Kilby Manufacturing Company, Cleveland, Ohio, made 825 of these filter press plates, 36 by 36 ins., weight 398 to 405 pounds each, with ¾ in. corrugations, finished on both sides. They machined easily, were close grained and took a fine polish. They used 25 to 30 per cent. steel scrap.

Only 7 were defective—less than 1 per cent.

In both cases these firms used a high percentage of steel scrap, got castings stronger and better than good grey iron, and lost less than 1 per cent. They do it every day.

You can save your costly hematite by using steel scrap, and get Semi-Steel castings with up to 42,000 pounds tensile strength—4,400 transverse,

by following instructions

— IN —

McLAIN'S SYSTEM.

Further Information FREE.

Mail Coupon Opposite.

McLAIN'S SYSTEM, 710, Goldsmith Bldg., Milwaukee, Wis., U.S.A.

Please send 48-page booklet "Semi-Steel," and full information free.

NAME.....

POSITION.....

FIRM.....

ADDRESS.....

3/14

ALLDAYS FOUNDRY EQUIPMENT.

WE ARE MAKERS OF ALL KINDS OF FOUNDRY PLANT:—
CLIMAX RAPID CUPOLAS,
CLIMAX ROOTS BLOWERS,
CORE OVENS,
FANS, LADLES,
MOULDERS TOOLS AND BELLOWS,
BRASS FURNACES, (OIL AND COKE FIRED),
BARROWS,
OVER-HEAD CRANES,
OVER-HEAD TRACKWAYS,
ETC., ETC.

WE ARE PREPARED TO QUOTE FOR ALL DESCRIPTIONS OF FOUNDRY EQUIPMENT

ATTENTION IS DIRECTED TO ALLDAYS

NEW IMPROVED CLIMAX RAPID CUPOLAS.

PRICES ON APPLICATION.

THE CLIMAX RAPID CUPOLAS ARE MADE IN ALL SIZES FROM ½ TO 20 TONS PER HOUR MELTING CAPACITY, WITH OR WITHOUT RECEIVERS, SPARK ARRESTERS, CHARGING PLATFORMS, HAND HOISTS OR ELECTRICALLY DRIVEN HOISTS.

ALL KINDS OF CUPOLAS FOR ALL CLASSES OF WORK.

ALLDAYS & ONIONS PNEUMATIC ENGINEERING CO. LTD.,

DEPARTMENT "B."

Great Western Works, BIRMINGHAM,
And at 58, HOLBORN VIADUCT, LONDON, E.C.

WE SUPPLY
THE
Leading Firms in the Trade with
FOUNDRY
BLACKINGS
OF ALL KINDS.

COAL DUST, CHARCOAL

PLUMBAGO AND BLACK-LEAD, CORE GUMS

and all Foundry requisites, and have done so since 1831.

WE SUPPLY

PLUMBAGO CRUCIBLES

for all classes of materials, any size, and of Best British Make.

I. & I. WALKER, Effingham Mills, ROTHERHAM.

OUR SPECIALITE IS STUDYING SPECIAL REQUIREMENTS.

KINDLY HAND US YOUR ENQUIRIES.

WRITE

THOS. E. GRAY & Co.,

Contractors to H.M. War Office,

71, LINCOLNS INN FIELDS, KINGSWAY, LONDON, W.C.

Telegrams—"Papplewick, London."
Telephone—1193 City.

BUY IN THE CHEAPEST MARKET.

LOWEST PRICES FOR—

Best Washed Welsh Foundry Coke.
Best Durham Foundry Coke.
Special Brass Foundry Coke.
Best Quality Ground Ganister.
Nottinghamshire Red Sands.
Rolled Sand and Facing Loam.
Pure Plumbago.
Limestone.
Smith's Breeze.
Best Large Lancashire Foundry Coke.
Best Yorkshire Steel Coke.
Derbyshire Foundry Coke.
Worcestershire Red Sands.
Superfine French & Belgian Sands (unequalled for Brass & Aluminium).
Coal Dust.
Anthracite, Steam and House Coal.
Smokeless Welsh Steam Wagon Coal.

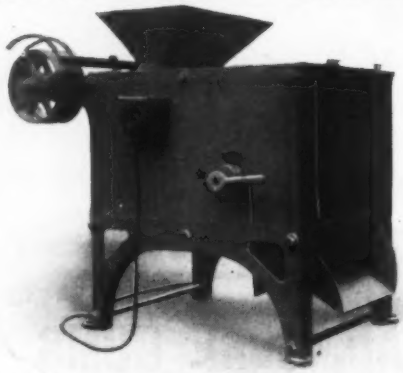
Your Money Returned

within a few months.

RECOVER THE IRON

from your sand and slag by

Electro-Magnetic Separators.



For particulars write to-day to

W. SILVERSTEEN & Co.

147, Cannon Street, LONDON, E.C.

Blacking of Quality means Economy.

OUR

Patent

MOULDER'S BLACKING

on account of its Superior Quality gives the most Satisfactory Results and is most economical in the end.

WE ARE THE ORIGINAL AND ONLY MAKERS OF PATENT BLACKING. THE STANDARD OF QUALITY WHICH HAS MADE IT FAMOUS IS STEADILY MAINTAINED.

Our other Specialties for Ironfounders, Steelfounders, etc., are—

Imperial Blacking,
Mineral Carbon Blacking,
Graphite or Black Lead,
Core Gum,
Wood Charcoal Blacking,
Plumbago Blacking,
Terra Flake, Coal Dust,
etc.

Enquiries Solicited.

GLASGOW PATENT MOULDERS BLACKING CO., LIMITED,

26-32, FLEMING STREET, PORT DUNDAS, GLASGOW.

Riddles and Sieves for Foundry use.
Steel Wire Casting Brushes.
Wire Machine Guards.
Every kind of Wirework.
Foundry Buckets.

PROCTER BROTHERS,

Riddle Makers, etc., LEEDS.

WRITE FOR CATALOGUES AND PRICES.

Our Patent Sand Mixer

will effect a considerable saving in the amount of new sand purchased.

In our own foundry we purchased 50 per cent. less sand during the past twelve months, while turning out a much larger tonnage of castings.

This machine enables old sand to be mixed with new sand in much greater proportion than has been hitherto considered desirable.

A thorough mixing and aerating of the sand is effected, allowing gases to escape easily. Previous milling is unnecessary.

The machine will deal with as much sand as two men can shovel into the hopper.

All bearings are dust-proof ball bearings; all gears are caseharden-ed steel and run in an oil bath.

Machines can be seen in operation in our foundries.

ALFRED HERBERT, LTD.,
COVENTRY.

FOR
IRONFOUNDERS
BLACKING,
BLACK LEAD,
CORE GUM, COAL DUST, Etc.

W C & Co. LTD.

WILLIAM CUMMING & CO., LTD.,

IRONFOUNDERS
FURNISHERS
Established 1840.

Works:
GLASGOW.
WEST BROMWICH.
CHESTERFIELD.
MIDDLESBROUGH.
FALKIRK.

Also
THE WELL-KNOWN
BRANDS

"IMPERIAL"
"EUREKA"
"VULCAN"
"CROWN"

Registered
Brand—
"SHALACO"

WRITE FOR QUOTATIONS.

BLACKING
PLUMBAGO
COAL DUST
CHAPLETS
STRAW ROPES
CORE GUM &c.

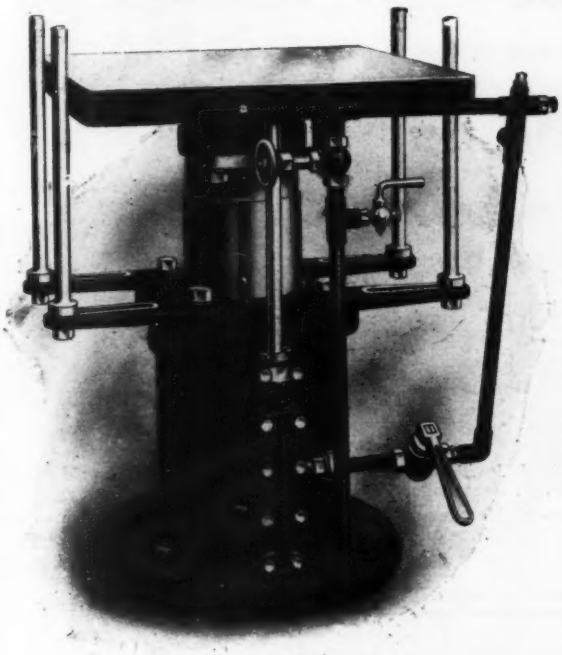
Agents for "GLUTRIN."

FOUNDRY STORES

Can ship cheaply to all British and Foreign Ports.

THOMAS WILKINSON & Co., Ltd.,
MAUFACTURERS,
MIDDLESBROUGH.

FRENCH RED MOULDING SAND AND SILVER SAND. THAMES LOAM AND LOCAL SAND.



"BRITANNIA"
JAR RAM MOULDING MACHINE

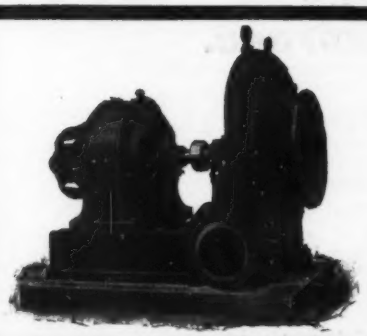
(Daimler and Wardles Patent), fitted with

SELF-CONTAINED LIFTING APPARATUS

Makers:

BRITANNIA FOUNDRY CO.,
Coventry.

London Agents: MURPHY, STEDMAN & CO., 180, GRAY'S INN ROAD, W.C.



Aktiengesellschaft Kühnle, Kopp & Kausch Frankenthal-Pfalz.

TURBO
BLOWERS,
COMPRESSORS,
VENTILATORS.

Represented by WITTING BROS., LTD., LONDON, E.C. 49, Cannon Street.

FOUNDRY PLANT.

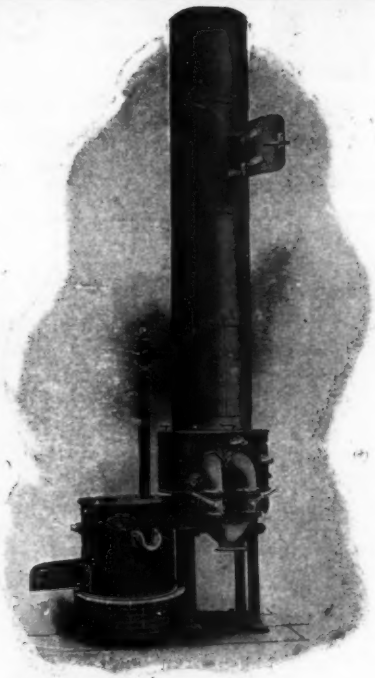
"Rapid" Cupolas,

with or without receivers or drop bottoms.

Roots' Blowers,

belt, steam-engine, or electro-motor driven.

Charging Platforms, Hoists, and Ladles.



ECONOMICAL RESULTS GUARANTEED.

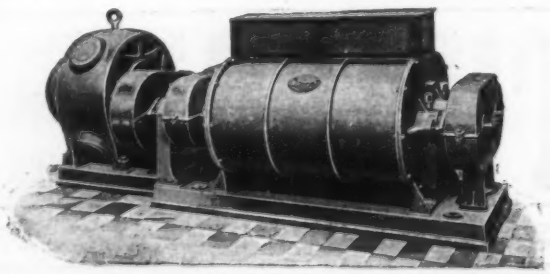
We are also Manufacturers of Steam Hammers, Smiths' Hearths, Centrifugal Pumps and Fans, High-Speed Engines, and the "Bradford" Patent Boiler Feed Pump.

We are the original makers of "Rapid" Cupolas as under Stewart's Patent. We make this intimation as other makers are introducing this description, which had become established as a synonym of Stewart's Cupolas.

CONTRACTORS TO HIS MAJESTY'S GOVERNMENT.

THWAITES BROS., LTD.,

Vulcan Ironworks, BRADFORD.



Telegrams—
"THWAITES, BRADFORD."

Telephone—
Nos. 3459 and 3460 BRADFORD.

London Office:
96 & 98, Leadenhall Street, E.C.

Catalogues on Application.

IMPORTANT TO IRONFOUNDERS.

MOULDING—
—MACHINES

FOR REPETITION FOUNDRY WORK.

Illustration of

HAND PRESS MACHINE

for Small Repetition Work, giving rapid and Economical Production.

Makers also of a

HAND RAMMING MACHINE

where a Deep Lift is required. Can be Up rated by

UNSKILLED LABOUR.

MOST EFFICIENT AND ECONOMICAL IN USE.

Also Makers - - of - - ROOTS' "ACME" BLOWERS.

FULL PARTICULARS FROM—

Samuelson & Co., Ltd., Banbury,

ENGLAND.

SEE OUR ADVERTISEMENT EVERY ALTERNATE MONTH.

BRASS MELTING OIL FURNACE

(OIL BLAST FURNACE & MUFFLE COMBINED)

BURNS COMMON PARAFFIN OR KEROSENE.

— SPECIALLY SUITABLE FOR —

Melting Brass, Copper, Aluminium, Zinc, Spelter, etc.

CASEHARDENING, ANNEALING, ETC.

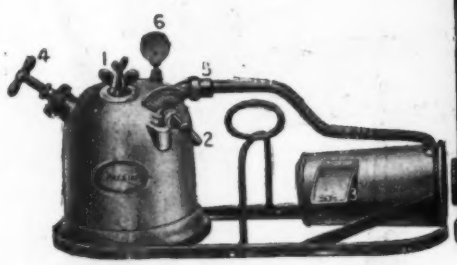
ALWAYS READY FOR USE.

MUFFLES ALL STEEL LINED OUTSIDE.

FURNACE CAN BE USED FOR OTHER HEATING PURPOSES WHEN NOT BEING USED WITH MUFFLE.

Sizes from 10 lbs. capacity, upwards.

Prices from
£7 10s. upwards.
Including Pressure Gauge, Muffle, etc., complete. . . .



SPECIAL ADVANTAGES.—For melting small quantities of metal, oil is much cheaper than coke. It is also considerably quicker and cleaner. The Furnace is fitted with a powerful Burner, and the Reservoir holds sufficient oil to melt a charge of metal without having to stop to refill. For large installations we recommend Furnace to burn crude oil, worked in connection with Blower or Air Compressor.

WE SUPPLY ALL THAT IS LATEST AND BEST IN METAL MELTING PLANT — CUPOLAS, TILTING FURNACES (COKE OR OILED FIRED) etc. . . .

MURPHY, STEDMAN & Co., Ltd.

180, Gray's Inn Road, LONDON, W.C.

THE SPECIALISTS IN THE LATEST TYPES OF FOUNDRY AND PATTERN SHOP EQUIPMENT.

AGENTS for:—

T. Davies & Sons. **Britannia Foundry Co.**
T. Wilkinson & Co., Ltd. **Stevenson & Co.**
Coldendale Iron Co. **Fortuna Machine Co.**
Mechanical Hammer Co. **Binderit Co.**
Best Core Machine Co. **Pattern Requisites, Ltd.**

Telephone—4268 HOLBORN.

Telegrams: "MURPHITES," HOLBORN, LONDON.

R&G HISLOP

Gas Fired DRYING STOVES,
ANNEALING OVENS, &c.
NO SMOKE. SAVING 50 per cent.
Adopted by the Leading Firms,

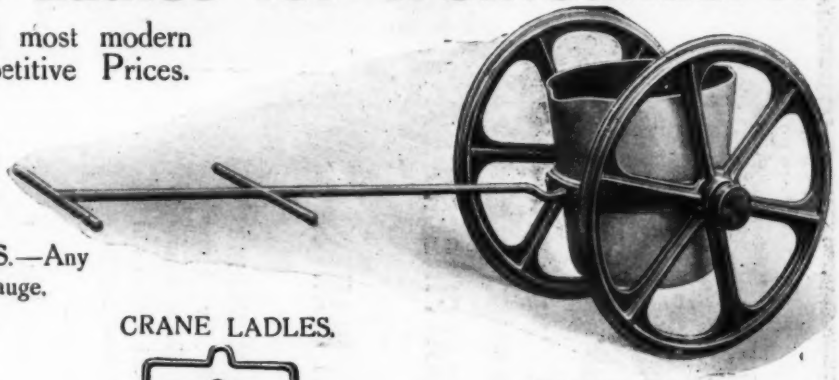
GAS ENGINEERS, UNDERWOOD HOUSE, PAISLEY.

STEVENSON'S
Welded Ladles for Ironfounders.

The Latest and most modern made at Competitive Prices.

Prices on Application

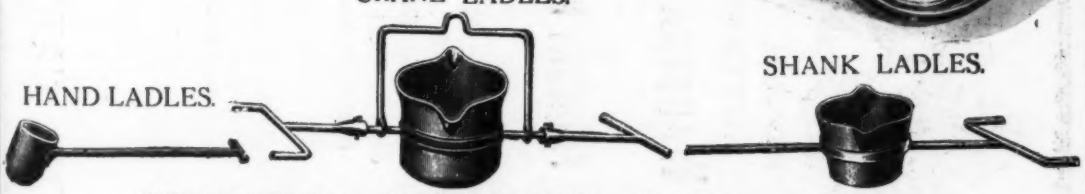
BOGIE LADLES.—Any capacity or Gauge.



CRANE LADLES.

HAND LADLES.

SHANK LADLES.



MURPHY, STEDMAN & CO., LTD.,
180, Gray's Inn Road, LONDON, W.C.
Telephone: 4628 HOLBORN.

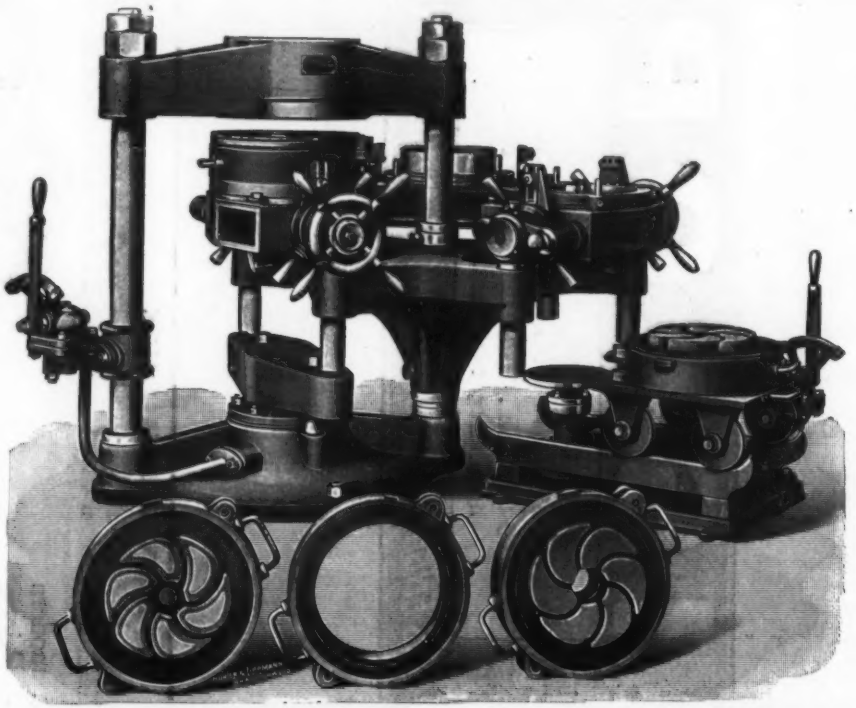
Telegrams:
"Advance, Piccy, London."
Telephone:
6032 City.

KÖNIGL. WÜRTT.
HÜTTENWERK
WASSERALFINGEN

FOUNDRY PLANTS.

SPECIAL MOULDING MACHINES for Iron, Steel, and Metal Foundries in latest design and approved construction.

Apply for Catalogues and full information to Sole British Representatives—



Hydraulic Reversible Moulding Machine with Three Reversible Plates, Guided in the Reversible Table, for Double-Sided Ramming. With patterns of belt pulleys.

CRITCHLEY, EVANS & CO.,
72-73, CARLTON HOUSE, REGENT STREET, LONDON, S.W.

KEITH-BLACKMAN CUPOLA FANS.

Power Bill reduced by 50 per cent. ! !

A well-known firm installed a "Keith-Blackman" Cupola Fan which enables them to easily get an output of 10 tons of metal per hour at a cost of 2½d. for power per ton melted, which is

LESS THAN ONE HALF THE COST

formerly incurred by a Blower of another make.

"Keith-Blackman" Cupola Fans are in extensive use in the Foundries of leading Engineering Establishments, etc., giving highly satisfactory results for - - - - -

ECONOMY & EFFICIENCY.

You can effect a saving by installing "K. B." Cupola Fans.

JAMES KEITH & BLACKMAN Co., Ltd.,

27, Farringdon Avenue, LONDON.

And at MANCHESTER, GLASGOW, NEWCASTLE, LEEDS, BIRMINGHAM, &c.

FOUNDRY BLACKINGS

FACINGS AND CORE ROOM SPECIALITIES.

PLUMBAGOS.

ROYAL.
SPANISH.
CEYLON.

FACINGS.

LITHITE.
TERRA FLAKE.

COAL DUST.
CHARCOAL BLACKING.

BLACKINGS.

GEOLITE.
RUABON.
IMPERIAL.

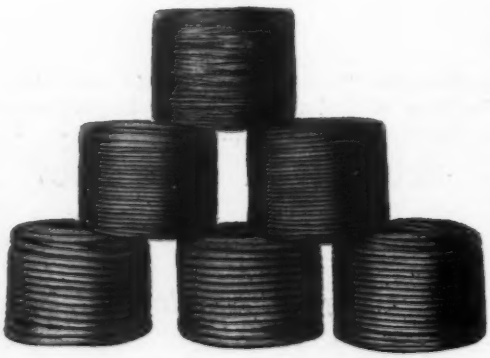
GANNISTER.
BOHEMIAN FLUX.
FIRECLAY.

MINERAL.
PATENT SCOTCH.
OAK CHARCOAL.

CORE ROOM SPECIALITIES.

CORE GUM.
KOREEN.
HANSOLENE OIL FOR CORES.
CORTREEN.

TAPIX.



VINXIT.
DRY BINDER.
STRYPA PARTING.
"TAPIX."
THE CORE VENT.

TRUE TO THE CORE.

JAMES EVANS & CO.

FOUNDRY ENGINEERS,
BRITANNIA WORKS,
MANCHESTER.

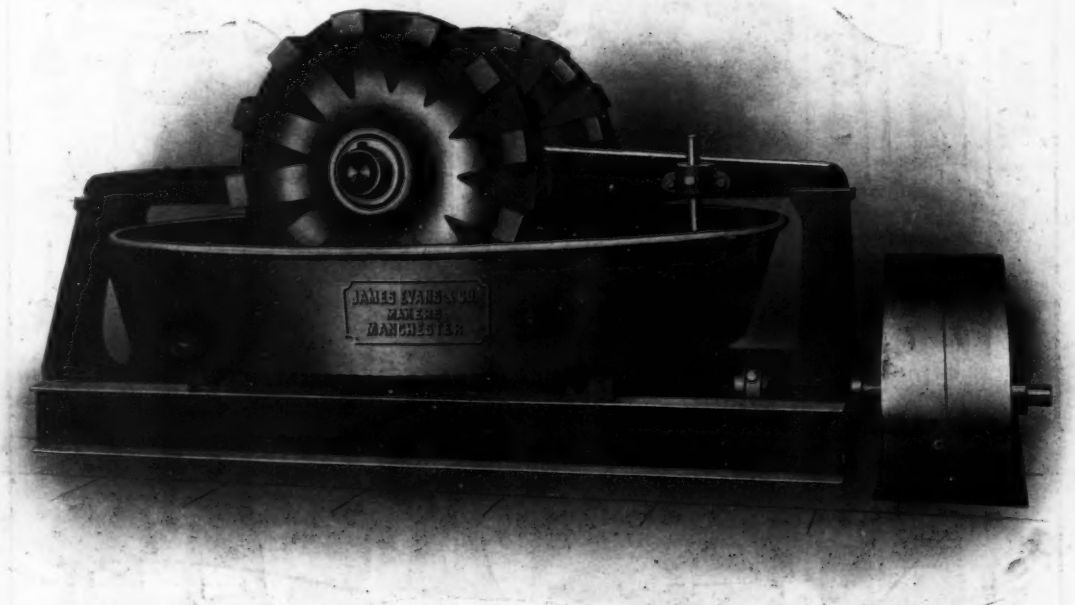
Telegrams: LADLES, MANCHESTER.

Telephone: 2297 CENTRAL, MANCHESTER.

Perfection comes from EXPERIENCE.

BUY YOUR
FOUNDRY REQUISITES
FROM **EVANS'S,**
THE **OLDEST** FIRM
IN THE TRADE.
THEY SUPPLY
EVERYTHING FOR THE FOUNDRY.

LADLES OF EVERY DESCRIPTION.



MILLS FOR ALL PURPOSES.

JAMES EVANS & COMPANY, FOUNDRY ENGINEERS,
Britannia Works, MANCHESTER.

Telegrams:—Ladles, Manchester.
Telephone 2297, Central, Manchester.

COMPLETE
Foundry Equipment.
Telegrams: "LADLES" MANCHESTER.
Telephone: "No 2297 CENTRAL" MANCHESTER.
REDISTIK FILLET
"TAPIX"
JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS. MANCHESTER.